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A HISTORICAL ANALYSIS OF TOTAL PACKAGE
PROCUREMENT LIFE CYCLE COSTING, AND
DESIGN TO COST

Joseph R. Busek

June 1976

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to the C-5A program. Life Cycle Costing attempts to determine the total acquisition and ownership costs of a system to provide aid in acquisition decisions. It is an integral part of the other concepts, but is limited by dependence on accurate data for its cost estimates. Design to Cost was introduced in 1971 and is now required to be used on all major and less than major programs. Its major objective is to obtain a system with acceptable performance at affordable costs by requiring that cost goals be established for production, operation and support. These concepts have restrained acquisition cost growth and showed that systems can be designed within cost goals.

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THESIS

GSM/SM/76S-3

Joseph R. Busek, Jr.
Capt USAF

A HISTORICAL ANALYSIS OF
TOTAL PACKAGE PROCUREMENT, LIFE CYCLE COSTING
AND DESIGN TO COST

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
in Partial Fulfillment of the
Requirements for the Degree of
Master of Science

by

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Graduate Systems Management

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Preface

This study is the result of ^{AN}my attempt to prepare a historical analysis of the three major Department of Defense efforts developed to control costs in the acquisition process. Some might argue that other concepts, such as Value Engineering, PIECOST, or Should Cost, should be included, however, ^{it is}~~I~~ believed that the ones presented here represent the approaches most relevant to individuals involved in program control. The concepts analyzed include Total Package Procurement, Life Cycle Costing, and Design to Cost.

The study is directed toward the individual with little knowledge of the concepts. It is designed to provide the reader with a general knowledge of what each concept is, when it is used, what some major ground-rules governing the concept's use are, and what some of the significant strengths and weaknesses of the concept are. Consequently, not all of the specifics concerning each concept are included. Additionally, the bibliography is, while not all inclusive, of sufficient breadth to enable the reader to find the specific details he may desire concerning any of the concepts.

I assume full responsibility for any errors that may be present in this study.

Joseph R. Busek, Jr.

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Abstract

The objective of this study was to accomplish a comprehensive historical analysis of Total Package Procurement, Life Cycle Costing, and Design to Cost. These concepts were developed in the Department of Defense as attempts to control the increasing costs associated with the acquisition and ownership of weapon systems. The analysis includes a tracing of the evolution and definition of each of the concepts, identification of major criteria for use of each of the concepts, consideration of the application of each of the concepts during the acquisition life cycle of a system, identification of the major strengths and weaknesses of each of the concepts, and a comparative analysis of the concepts.

In 1964 Total Package Procurement was the first concept introduced specifically to attempt to control acquisitions costs. Its main objective was to eliminate cost overruns in the acquisition process. It proposed to accomplish this by competing the development, production, and support of a system in a single contract, which was to be firm fixed price. However, the concept was eliminated as an acquisition approach in 1970 due primarily to problems encountered during its use on the C-5A transport program.

The next concept analyzed was Life Cycle Costing. The idea of considering life cycle costs in acquisition was seen in Government Accounting Office decisions as early as 1929, but the concept did not receive emphasis until the 1960's. Its objective is to attempt to determine the total costs of acquisition and ownership of a system and then use this information as an aid in decisions concerning acquisition. It is an integral part of Total Package Procurement and Design to Cost. It is limited by its dependence on accurate data for its cost estimates.

The concept developed to replace Total Package Procurement was Design to Cost. It was formally introduced in 1971 in Department of Defense Directive 5000.1 and is now required for use on all major and less than major programs, unless a waiver is granted for specific reasons. Its main objective is to obtain a system with acceptable performance at affordable costs. It accomplishes this by requiring that cost goals be established for the production, operation and support of the system.

These concepts have been effective in the restraint of cost growth in the acquisition process. Total Package Procurement reduced cost overruns significantly. The few examples cited for Life Cycle Costing in this study alone show savings in excess of \$100 million. Design to Cost has demonstrated that systems meeting

performance requirements can be designed to meet cost goals. Refinements in Life Cycle Costing and Design to Cost, as more is learned about each concept, should continue to increase the effectiveness of these concepts in achieving their goal of controlling the total costs of a weapon system.

I. Introduction

Three key Department of Defense cost control concepts have been developed in the past 15 years. These concepts are Total Package Procurement, Life Cycle Costing, and Design to Cost. Each concept was developed in the Department of Defense specifically to attempt to control the increasing costs associated with the acquisition and ownership of weapon systems. This thesis will be directed toward an analysis of these concepts.

Objective

The objective in this thesis will be to accomplish a comprehensive historical analysis of Total Package Procurement, Life Cycle Costing, and Design to Cost. The specific subobjectives to be used to accomplish the goal of the overall objective are as follows:

- a. Trace the development and evolution of each concept in terms of historical background up to current status and definition.
- b. Identify the criteria for use of each concept.
- c. Identify when the concept is intended to be applied during the acquisition life cycle of a system.
- d. Identify the major strengths and weaknesses associated with the utilization of each concept.
- e. Perform a comparative analysis of the concepts.

Methodology

The methodology used to accomplish the thesis was a comprehensive research of pertinent literature concerning each concept. Sources of information included journal articles; Department of Defense Directives; Department of Defense guides and handbooks; Government Accounting Office reports; special reports; Air Force regulations; Air Force Systems Command and Logistics Command pamphlets, reports and briefings; theses; and other professional studies.

These sources were then used to accomplish an analysis of each of the concepts identified in the objective. The research approach consisted of an overview analysis of the material followed by identification of key points in each document. The key points in each document were then evaluated to determine if they should be used in the study based on the writer's assessment of how the item aided in achieving the writer's objective.

An example of how the analysis was accomplished is provided for Design to Cost.

a. The background of this concept will be traced from development to present form. The many interpretations of the definition of the concept will be presented including how this affected use of the concept.

b. The next step will be to develop a set of criteria for the concept. These will be synthesized from the researched literature.

c. Next, the point in the acquisition life cycle where the concept must be specified will be examined.

d. The strengths and weaknesses of the concept will be presented. Specific examples will be cited.

e. Finally in a separate chapter the concept will be compared with Total Package Procurement and Life Cycle Costing.

Results

This thesis will provide a current analysis of three key Department of Defense cost control concepts, which have been or are being used in the acquisition of new weapon systems. This thesis will provide a comprehensive development of each concept which will enable the reader to obtain a working knowledge of each concept. This thesis will provide the reader with a general outline of what the use of each concept involves for him.

Assumptions

The following assumptions were used in this thesis:

a. Total Package Procurement, Life Cycle Costing, and Design to Cost have been the principal approaches developed to establish control over increasing costs.

b. Cost control will continue to be of major importance during the foreseeable future. Consequently the effective manager needs to know what approach he is using and why he is using it, so that he can make intelligent decisions.

Definitions

Certain terms used in this thesis have been defined in different ways by different writers. In order to avoid misinterpretation those terms are now defined as they will be used in this thesis.

Acquisition Life Cycle - It consists of five phases (Conceptual, Validation, Full-Scale Development, Production and Deployment) with three key decision points (Program, Ratification and Production Decision) between each of the first four phases (2:4).

Conceptual Phase - Initial period when the technical, military, and economic bases for acquisition programs are established through comprehensive studies and experimental hardware development and evaluation (2:4).

Validation Phase - Period when major program characteristics are refined through extensive study and analyses, hardware development, test and evaluations. The objective is to validate the choice of alternatives and to provide the basis for determining whether or not to proceed into Full-Scale Development (2:4).

Full-Scale Development Phase - Period when the system/equipment and the principal items necessary for its support are designed, fabricated, tested, and evaluated. The intended output is, as a minimum, a pre-production system which closely approximates the final product, the documentation necessary to enter the production phase, and the test results which demonstrate that the production product will meet stated requirements (2:4).

Average Unit Flyaway Cost - The cost per unit which includes, as appropriate, those costs experienced in the procurement of the basic unit to be fabricated (airframe, hull, chassis), propulsion equipment, electronics, airborne weapons, armament - fire and bombing systems, other government-furnished property, engineering changes and first destination transportation. Excluded from this cost are all initial spares and spare parts and training requirements (1:39).

Several definitions were analyzed for each cost control concept. The following definitions were selected as the ones best revealing the essence of each concept.

Total Package Procurement - Concept conceived by the Air Force that envisions that all anticipated development, production, and as much support as is feasible of a system throughout its anticipated life is to be procured as one total package and incorporated into one contract containing price and performance commitments at the outset of the acquisition phase of a system procurement (84,3).

Life Cycle Costing - The consideration of life cycle costs, or segments thereof, in various decisions associated with acquiring an item of equipment or defense system (4,1).

Life Cycle Cost - An acquisition or procurement technique which considers operating, maintenance, and other costs of ownership as well as acquisition price, in the award of contracts for hardware and related support. The objective of this technique is to insure that the hardware procured will result in the lowest overall ownership cost to the Government during the life of the hardware (46,1-1).

Design to Cost - As a philosophy Design to Cost means the control of system acquisition, operating and support costs; example - managing the life cycle cost. As a quantitative contractual goal, Design to Cost in general practice is defined as the average unit flyaway cost with visibility maintained in parallel with the total life cycle cost (11,1).

II. Background

Appreciation of why cost control has become a significant factor in acquisition strategy requires an understanding of past acquisition processes. Consequently this chapter will trace acquisition in the Air Force from its earliest days to the present where cost control has become a prime objective in the Department of Defense.

Development of Acquisition Philosophies

The Early Days. The genesis of what has subsequently become known as "weapon system", "program", or "system acquisition" management began in the mid-1920's at Dayton, Ohio. At that time a Materiel Division to the Army Air Corps was created which included the functional management of experimental engineering, procurement, production engineering, and supply and maintenance (63:2).

This functional management approach meant that individual groups were formed with responsibility for the individual parts of the system. This meant that there were separate groups concerned with armament, power plant, production engineering and electronics (55:93). This type of acquisition strategy resulted in several problems. The first was a lack of weapon system appreciation. Each group was concerned with its own specific part, so that as the system passed through the

acquisition life cycle performance suffered, costs increased and delays occurred. A second problem was inadequate reliability. Finally there was a lack of thorough and timely development of logistic support systems (87:61). The B-47 airplane, in one writer's view, highlighted the deficiencies of an acquisition process with little or no centralized control over the total system. In reviewing the history of acquisition management at that time he commented: "The difficulty in obtaining B-47 aircraft in which all component parts functioned in unison for an acceptable length of time was a case in point." (63:6).

The Systems Approach. Partly as a result of the lessons learned from the B-47 problems the Air Force initiated the concept of the complete weapon system. A complete system was considered to be one in which the aircraft or missile, its components, supporting equipment, and USAF activities to implement its use would be planned, scheduled, and controlled, from design through test, as an operating entity. The objective of this approach was to ensure, as far as possible, that a balanced and complete combat-ready weapon system would be produced and ready for use when needed by the Air Force (63:6).

Concurrency. The next significant development in acquisition strategy was the use of the "Concurrency" approach to system development. This approach was

developed in the late 1950's in response to the perceived threat of Soviet advances in missile development. Concurrency was a strategy which required the overlap of the development, testing, production, and operational cycles. The objective was to shorten development lead time and increase the operational life of a weapon system (68:237-250). What it also meant, without saying it, was that the prime objective was to get a system operational in the shortest possible time without regard for the costs involved. This caused substantial cost overruns in systems developed using the Concurrency strategy. It also tended to eliminate the use of prototypes, which had been used since the 1930's.

The McNamara Influence - Cost Control

In 1961 Robert McNamara became Secretary of Defense. Almost immediately there was a shift from the rapid development of systems to a least cost approach. This writer has identified two reasons for this shift. First, the threat that caused the rapid development of new systems in the late 1950's was determined to have been less than previously thought. Second, McNamara's business background emphasized the development of a product for the minimum possible cost. He apparently believed that the Department of Defense could be managed the same way (86:2). Paper assessments were used as the

primary method to determine whether or not to develop a particular system. These paper analyses were substituted for the production prototype development processes, which were used earlier (87:61).

Total Package Procurement. Concurrency had resulted in cost overruns of up to 700 per cent (61:16). Mr. McNamara intended to eliminate this problem. This commitment in turn led to the development by Mr. Robert Charles, then Assistant Secretary of the Air Force (Installations and Logistics), of the Total Package Procurement concept. He first identified this concept in mid 1964. One of the basic objectives of the concept was to reduce costs over the development, production, and support cycles of a system's lifespan.

Life Cycle Costing. Up to 1964 the idea of considering the total costs associated with a project had received attention, but little action. The development of Total Package Procurement changed this view. One of the prerequisites to successful implementation of Total Package Procurement was development of an estimate of total life cycle costs. Consequently substantial efforts were initiated within the Department of Defense to develop accurate assessments and estimates of what the total costs would be for a system while it was still in the conceptual or validation phases of acquisition.

The first major system to be acquired using Total Package Procurement was the C-5A transport. At the

time Total Package Procurement was applied to the C-5A it seemed that the aircraft represented precisely the type of program to which the concept should be applied (61:x11). However this was not the case. One of the results of the C-5A problems was to discredit the Total Package Procurement concept as a means to acquire new systems.

Design to Cost. Although Total Package Procurement was discredited, cost control still remained a major objective within the Department of Defense. As a result two actions occurred. First, the use of prototypes and contractor fly offs regained acceptance as one means to ensure a system would satisfy requirements before production funds were expended. Second, a new concept to control costs was developed. This was Design to Cost.

Development of Design to Cost completes the evolution of cost control concepts to the present. Design to Cost represents a stated requirement to place cost on an equal basis with performance and schedules as a parameter in system acquisition. The concept also emphasizes a need to consider total life cycle costs in the early stages of the acquisition life cycle.

This brief history has shown that cost as a major consideration in system acquisition had not entered the picture until the 1960's. It has also shown that three principal concepts have been developed to attempt to restrain cost growth in system acquisition and

ownership. These concepts are Total Package Procurement, Life Cycle Costing, and Design to Cost.

In subsequent chapters each of these concepts will be analyzed in detail. First they will be studied individually and then they will be compared against each other to see how they differ and also how they are similar.

III. Total Package Procurement

The Total Package Procurement concept represented the first major effort by the Department of Defense to impose cost control in the acquisition of new defense systems. In the time prior to Total Package Procurement, contractors had competed only for the development portion of major acquisition programs. By the early 1960's this competition was mostly limited to a design or technical competition with little or no hardware being built (84:10).

Once a contractor won the development contract the expertise he gained resulted in additional development or production contracts generally being negotiated in a sole source environment. The resultant lack of competition caused little incentive to control costs, as the additional development and production contracts were negotiated. One result was cost overruns, where costs exceeded estimates. In one case costs exceeded estimates by approximately 700 per cent (61:16). It should be emphasized that the overruns did not result solely from the lack of competition. There were other factors, such as changes in performance requirements during development and production that contributed to the overruns, but the sole source environment was a contributing factor. The intent of Total Package Procurement was to extend contractor competition to

the production and support areas as well as development. It was believed that this would reduce part of the previous cost overruns.

This chapter will review the Total Package Procurement concept for two reasons. First, the concept represented the first major effort to initiate cost control in systems acquisition. The second is that the later concepts of Life Cycle Costing and Design to Cost follow many of the criteria established in the Total Package Procurement concept and have some of the same strengths and weaknesses, as well.

Historical Evolution

In the late 1950's Soviet advances, such as Sputnik, caused concern in the United States. The result was a rapid and substantial development of military capability in the United States (63:11). The acquisition strategy developed to accomplish this rapid development of new systems was "Concurrency." Under Concurrency acquisition of a system was accomplished in a parallel fashion where development, testing, production, and deployment might be occurring at the same time (68:240). This strategy resulted in cost overruns from original estimates. However an additional reason could be advanced for part of the overrun problem. This reason was a lack of competition. Competition was generally limited to the contract definition phase of acquisition.

In the 1960's, when Total Package Procurement was developed, the phases of acquisition were different than they are today. The first phase was a concept formulation phase where extensive parametric studies were accomplished to define performance requirements for a system. The next phase was termed contract definition. During this phase contractors qualified to submit bids were determined by the government. Qualified contractors were then invited to participate in the program. If a contractor decided to participate, he was given funds by the government to develop a design and bid. The contractors' designs and bids were then evaluated by the government. A winning contractor was selected and the final phase of acquisition entered. This phase included development and production. Figure 1 shows this acquisition flow (61:31).

In 1964 a new program to reduce cost overruns was developed. The new program was called Total Package Procurement. Mr. Robert Charles, then an Assistant Secretary of the Air Force, introduced the program. In speeches concerning the new Department of Defense approach to acquisition, Mr. Charles emphasized the following basic points.

"...under appropriate circumstances, we should move much more in the direction of competing entire programs - development, production, and the support that goes with a system - at the beginning" (22:46).

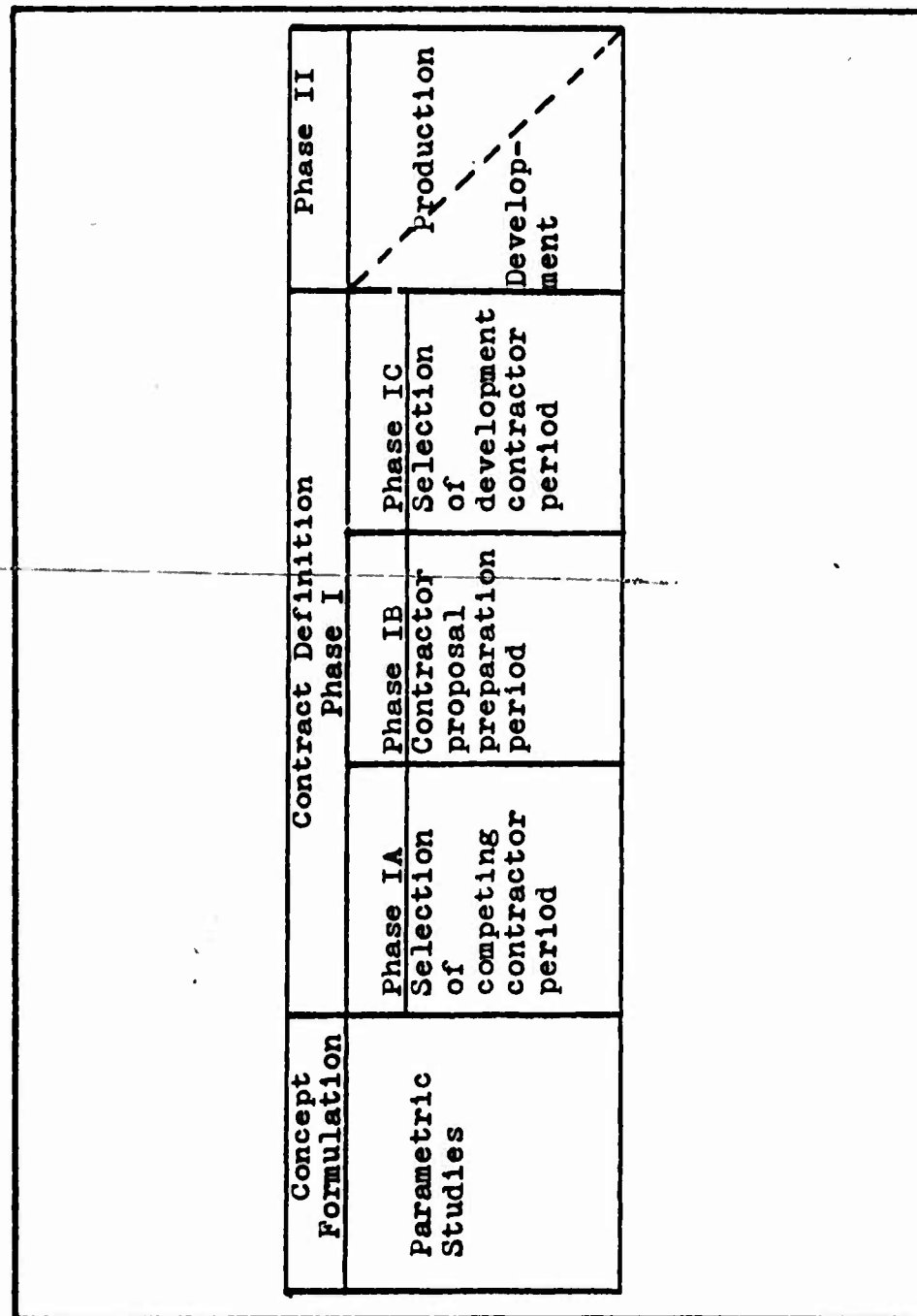


Fig. 1. Phases of the Acquisition Process in the 1960's

He also indicated that use of a Total Package approach would (1) reduce "buy-in" bidding and (2) provide a needed spur to emphasize simplicity and economy of design during the development stage (22:46). The term "buy-in" meant that a contractor would bid a price substantially less than anticipated costs or at a very low profit level on development contracts. After he won the initial contract the contractor would recover his losses during negotiations for the contracts for continued development and production of the system (84:10). Finally Mr. Charles concluded that under a Total Package Procurement concept:

 "...the contract target cost for the entire program, having been established competitively, would remain firm throughout the contract, except for changes in the work itself" (22:46).

Basically Total Package Procurement was designed to (1) extend competition beyond the design stage of a system's development, (2) establish firm performance requirements, schedules and production quantities for a system at the beginning of the contract definition phase, and (3) levy a firm fixed price on the contractor who received the contract.

In approximately this same time frame the Air Force was actively considering development of a new heavy transport aircraft. As studies for the aircraft continued, it was determined that the transport might

be a candidate for use of the new concept. Former Air Force Secretary Zuckert concurred and recommended use of the concept on the program to the Secretary of Defense. In February 1965 the heavy transport aircraft (the C-5A) was formally designated as the first user of the Total Package Procurement concept (61:25).

In September 1965 Lockheed was awarded the contract for the development and production of the C-5A. The contract included special provisions directed toward implementing a total package procurement. These provisions or clauses were designed to maintain three kinds of contractor commitments--clauses to maintain price commitments, clauses to maintain performance commitments, and clauses to maintain schedule commitments (84:11). The contract was also firm fixed price plus incentive fee.

Other programs, besides the C-5A, used the concept. These included the Short Range Attack Missile (SRAM), Fast Deployment Logistic (FDL) Ship, and Light Observation Helicopter Avionics Package (LOHAP). The A-7A Navy aircraft program was initiated prior to the formal announcement of the Total Package Procurement concept, but it also utilized the total package approach (84:95). The C-5A program was the most visible user of the concept due to the size of the program. The initial program price was set at approximately \$1.8 billion. The next most expensive was the FDL ship with an initial estimate

of \$500 million (84,21).

This writer will not develop a thorough history of how the concept was applied to the C-5A program nor address the difficulties encountered in the program. A comprehensive historical review of the program is provided in an Air Force Institute of Technology thesis: History and Analysis of the C-5A Program: An Application of the Total Package Procurement Concept (61).

As a result of the problems encountered during the C-5A program, Total Package Procurement was discredited. In May 1970, former Deputy Secretary of Defense Packard issued a memorandum that stated that fixed price contracts would not normally be used until development of the system had reached a point where the production design was well specified. He also indicated in the same memorandum that cost plus incentive fee contracts were preferred for both advanced development and full-scale development (56,58). This memorandum effectively ended the Total Package Procurement approach to acquisition.

The concept was definitively eliminated as an acquisition approach in Department of Defense Directive 5000.1 in July 1971. In paragraph III C.7., the directive stated:

"It is not possible to determine the precise production cost of a new complex defense system before it is developed; therefore such systems will not be procured using the total package procurement concept or production options that are contractually priced in the development contract" (57,5).

In this section the reasons why the Total Package Procurement concept was introduced were highlighted. Likewise the initial specification of the concept was identified, as was the demise of the concept.

Definition

In this section the Total Package Procurement concept is defined.

"Total Package Procurement as conceived by the Air Force envisions that all anticipated development, production, and as much support as is feasible of a system throughout its anticipated life is to be procured as one total package and incorporated into one contract containing price and performance commitments at the outset of the acquisition phase of a system procurement" (84:3).

As can be seen in this definition, the concept was an attempt to eliminate the practice of incrementally procuring development production, and logistic support for major systems programs. The ultimate goal of the concept was to incorporate the complete development, production and support of a program in a single contract. The initial programs undertaken using this concept included only part of the support area. Requirements, such as spares and depot Aerospace Ground Equipment, were not included in the contracts (84:16).

Criteria for Use of Total Package Procurement

In this section major criteria for use of the Total Package Procurement concept will be presented.

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The intent is to identify the major points which were supposed to determine use of the concept.

1. The system to be developed should represent low technological risk (47:52). Since a firm price would be established before the system went from design to hardware, Total Package Procurement should be used where a well established technological base existed. It was considered essential for effective use of the concept. Initially the C-5A program appeared to fit this criterion (61:xi1).

2. Use of Total Package Procurement required a precise definition of mission, performance, production rates, and schedule by the user. In order to bid intelligently the competing contractors needed to know precisely about all aspects of the system. Additionally the user had to be certain that the system would have few changes in it as it was developed (61:23-25).

3. Cost effectiveness was a criterion in application of the concept. This meant that the lowest life cycle costs at a specific level of effectiveness or the highest level of effectiveness for a given cost would be determined (84:70). This information would be one basis for determining contract award.

4. The concept required adequate time in the contract definition phase for competing contractors to develop designs. This would enable the contractors to design for more efficient and economical production, reliability and field maintainability.

In this section a few of the significant criteria which were supposed to be used in the implementation of Total Package Procurement were reviewed. These items highlight the major factors which were to be used in determining whether or not to use the concept for a specific program. Next strengths and weaknesses of Total Package Procurement will be examined.

Strengths

In this section the major strengths of Total Package Procurement will be presented. The items identified represent a synthesis of findings in research of the concept. There has been no attempt to rank order the items, because they are closely related with respect to individual importance. Additionally a brief review of how the C-5A program followed each identified strength will be presented.

The first major strength of Total Package Procurement was the inhibiting of "buy-in" bidding. The competing contractors strived more vigorously to establish realistic prices for the total package programs, even committing company funds beyond those provided by the Air Force to prepare designs and bids. On the C-5A program it was estimated that \$71.0 million were used by the competing contractors in bid preparation. Only \$25.0 million of this amount was provided by the Air Force (84,21).

However, cost estimates for the C-5A went from approximately \$1.9 billion in 1965 to over \$3.0 billion in 1969. Was this overrun a result of "buy-in" bidding? A special C-5A review council in its findings specifically noted that Lockheed's low estimate showed no evidence of "buy-in" bidding. Reasons identified for Lockheed's low bid included (1) overoptimism in engineering and fabrication, (2) sharp escalation of inflation over projections, (3) increased costs caused by the need

to use special materials, and (4) increased costs caused by an active aircraft industry versus the stagnant industry projected by the company(85:53-54). All of these factors combined to cause a part of the overrun.

Another view of the Lockheed bid was provided in the Poncar/Johnston thesis. In that thesis the writers presented the opinion that Lockheed underbid because (1) it believed that the contract permitted an adequate profit even with overruns, (2) it believed getting the contract would give the firm an advantage in the commercial market, and (3) it believed the Air Force would make program changes, which would permit contract renegotiation (61:158). This writer believes this could be considered a form of "buy-in" bidding.

However, the Total Package Procurement concept did obviously inhibit the practice of "buy-in" bidding. This is confirmed by the fact that the overruns on the C-5A were only approximately 45 per cent as projected in 1969 (85:53) and could partially be blamed on factors other than "buy-in" bidding. This can be compared to an average overrun of approximately 200 per cent in programs of the 1950's, which indicates a better estimate of costs under Total Package Procurement.

Another strength of the concept was a better definition of design specifications. These were performance requirements, schedules, and production

quantities. The government in order to use a total package approach had to define, early in the program, specifically what it wanted, when it wanted it, and how many it wanted.

However, design specification could also be considered a major weakness of the concept. In a study of Total Package Procurement, the Logistics Management Institute concluded that early firming up of design specifications, particularly performance requirements, could result in a sacrifice in technical design. The institute further indicated that it would be difficult to take advantage of later advances in the state of the art. But the same report also stressed that the concept could be an effective procurement technique when applied to programs that could be considered state of the art (84:63-64). This writer stressed the need to use the concept on programs with a well-established technological base in the discussion of criteria for use of the concept.

With respect to the C-5A program, it was reported in 1969 that performance requirements were met with no design changes that degraded specified mission performance requirements (85:53).

Another strength of the concept was the extension of contractor competition to more phases of the acquisition process. The contractors would compete not only for the full-scale development of the system but also

for the production and support of the system in deployment. This was designed to motivate the contractor to design for economical production and reliable and simplified maintenance of the system from the beginning of design. It was also to provide stability for the contractor, because he would know he had a long term commitment, so that he would have a greater motivation to invest in facilities. It would also provide a firmer planning base (84,59). The total package approach would also extend his responsibility over the entire acquisition life cycle.

This strength was substantially realized on the C-5A program. The government provided funds to three potential prime contractors to prepare designs and bids. The contractors were Boeing, Douglas and Lockheed. All submitted bids on the total package. However one of the major objectives of the strength - design for efficient production - was not met. The three contractors expended over nine months in preparing designs. However, two of the contractors failed to satisfy major performance requirements in their designs. These were Douglas and Lockheed. Lockheed then resubmitted a much revised design in three days. Lockheed was subsequently awarded the contract. During development and into production it was realized that these drastic design changes developed with no detailed analysis had failed to anticipate significant production problems. Therefore,

much more complex production procedures than were projected by the company resulted (61:165). Consequently no cost savings were achieved through efficient production.

Total Package Procurement was intended to force long range planning. Both the government and the contractor would be required to project their requirements and abilities to meet those requirements into the future at least five years. This planning would enable the government to determine early whether or not sufficient resources were available to proceed with a program with specific production quantities and schedules. Likewise, the contractor would have to consider the out year effects on him. He would have to consider possible inflation, a dynamic or stagnant economy and other factors in his cost estimate.

The Total Package Procurement concept failed to consider one key aspect of planning. Planning, especially long range planning, is an estimate that must be updated as circumstances change. The Total Package Procurement concept contained no provision to revise a program, if factors affecting the program changed.

The C-5A program graphically showed how the strength quickly turned into a major weakness. Inflation rose more rapidly than Lockheed projected. Lockheed planned for a stagnant aircraft industry, but the Viet Nam war caused a dynamic industry. This forced costs up (61:157-160). Consequently it is clear in retrospect that the concept

Inhibited "Buy-in" Bidding

Caused Better Definition of Performance Requirements, Schedules, and Production Quantities

Extended Contractor Competition in the Acquisition Life Cycle

Caused Long Range Planning

Fig. 2. Summary of Total Package Procurement Strengths

needed a provision for change, if original planning factors proved significantly inaccurate.

These were the principal strengths of Total Package Procurement. They are summarized in Figure 2. The concept represented a radical departure from previous acquisition practices. It was a complex strategy requiring significant efforts by the government and contractors. Its first application to a program of the size of the C-5A magnified the potential deficiencies of the strengths of the concept. In retrospect it does now appear, however, that the strengths of the concept did represent important advances in bringing cost control to the acquisition process.

Weaknesses

In this section the significant weaknesses of Total Package Procurement will be reviewed. The specified weaknesses represent a synthesis of those identified during research of the concept. It should be noted that most deficiencies attributed to Total Package Procurement, as a result of the C-5A program, were mostly a failure to follow the criteria of the concept, rather than weaknesses in the concept itself. Additionally it should be recognized that each of the strengths identified in the previous section could also be labelled weaknesses under the right conditions. The previous discussions of the problems of the C-5A program, which followed each strength, illustrated this point.

A major weakness of the concept was a lack of understanding about how much program monitoring and control were needed. The idea behind a fixed price contract is to let the government take a "hands-off" policy toward a program once the contract is awarded. The contractor is to be totally responsible for management of the program with freedom to respond to problems, as he encounters them.

One report in its study of Total Package Procurement indicated that in the contractors' view the government appeared to be exercising an undue amount of managerial control for a fixed price contract. The report added that the contractors also believed the government required an inordinate amount of data information in Total Package Procurement (84:30-31).

The C-5A program illustrates the lack of understanding about how much program monitoring and control were needed. During the first year of the contract the Air Force exercised full control and supervision over the contractors, as it had done in cost type contracts of past acquisitions (85:53). However, it then moved to a management philosophy of "disengagement". The basic idea of disengagement was to eliminate many contracting officer or plant representative approval requirements. This was done to eliminate the requirement for affirmative government action before contractor decisions affecting the program were made (84:30).

This change, however, caused deficiencies that were not corrected as rapidly as they should have been.

It is this writer's judgement that a clear understanding of program monitoring and control was not present in Total Package Procurement. As the discussion showed there was confusion and a lack of understanding about how much government control was necessary for a total package approach.

Another major weakness of the concept was its attempt to fix a price on a paper concept for a future system (39:60). There are too many unknowns in taking a design from paper to reality. There is too much potential for cost growth. There are risks involved even with a well developed technological base. Finally it should be recognized that the costs identified by the contractor were really estimates and should have been treated that way with provision for periodic updating (28:13).

Another significant weakness was the lack of flexibility contained in the concept. The specific definitions of performance requirements, schedules, and production quantities included no flexibility for changes or tradeoffs between costs, performance, and schedules. This restricted the ability of the contractor to perform in the most cost effective way as he moved from design to actual hardware (85:52).

These were the most significant of the weaknesses

Lack of Understanding Concerning
Monitoring and Control

Attempt to Fix a Price on a
Paper Design

Lack of Flexibility

Fig. 3. Summary of Total Package Procurement Weaknesses

of Total Package Procurement. They are summarized in Figure 3. Were they responsible for the failure of the concept? It is this writer's view that the major reason for the failure of the concept was its use on the C-5A program. The C-5A program was a multi-billion dollar program, which, while not exceeding the state of the art, approached state of the art limits due to the enormous size of the aircraft. It was also a complex program. It was also a program with a compressed schedule, which meant limited development time would be available (61:156). Finally it was a highly visible program due to its size. The result was that when the program experienced difficulties, Total Package Procurement received part or most of the blame. As a result the concept became politically discredited. Total Package Procurement suffered when labels, such as "the golden handshake" and "the sweetheart clause", were applied to the repricing formula, which formed part of the contract provisions of the concept. This formula provided for adjustments to prevent intolerable loss or profit for the contractor (85:52). In 1970 the Department of Defense terminated use of the concept in a political move to stifle further criticism of Department of Defense acquisition policies.

In this chapter the development of the first major Department of Defense effort to control costs

has been presented. Total Package Procurement, as will be seen in later chapters, formed the foundation on which Design to Cost was built. Additionally many of the basic criteria and objectives in Total Package Procurement can be seen in both Design to Cost and Life Cycle Costing.

IV. Life Cycle Costing

In Chapter two it was briefly noted that estimates of life cycle costs were a prerequisite for implementation of Total Package Procurement. It was also noted that the Design to Cost concept required estimates of total life cycle costs for implementation. Consequently it is important to analyze the Life Cycle Costing concept.

Research of the Life Cycle Costing concept has determined that its initial promulgation cannot be identified as definitively as Total Package Procurement or Design to Cost. Additionally research has determined that the concept cannot be examined at specific points of application during the acquisition life cycle, as were Total Package Procurement and Design to Cost. The Life Cycle Costing concept is rather a pervasive philosophy or objective throughout the acquisition life cycle of a system.

In Total Package Procurement, life cycle cost estimates were used during the contract definition phase for source selection. In Design to Cost, life cycle cost estimates are used in both the conceptual and validation phases. These estimates influence design and tradeoff decisions. These estimates also form part of the source selection criteria. In the full-scale development, production, and deployment phases data are gathered which validate the previous

estimates, as well as, aid in preparing estimates for new systems entering the acquisition process. A more comprehensive examination of the pervasive nature of the concept will be accomplished in the section on application of the concept during the acquisition life cycle.

Historical Evolution

The history of the evolution of Life Cycle Costing is not as definitive as Total Package Procurement. In fact it is quite nebulous. However, there are some specific events that mark significant developments in the concept as a means to estimate and control costs.

As early as 1929 the General Accounting Office made decisions that mentioned the need to consider total costs in contracts let by the government, not just acquisition costs (66:D-2).

Applicability to Department of Defense procurements was tentatively identified in 1947. In the Armed Services Procurement Regulations issued that year there was reference to the fact that contracts should be awarded on a basis of price and "other factors". Review of the supporting report from the Senate Committee on the Armed Services indicated that the term "other factors" was to include consideration of "ultimate cost" in procurement activities (20:1).

Further development of Life Cycle Costing as a

philosophy occurred in 1963. At that time the Assistant Secretary of Defense (Installations and Logistics) initiated a study of the effect that price competition could have on life cycle equipment costs. This initial effort was directed toward award of production contracts for minor subsystems, assemblies, subassemblies, and parts (20:1).

In 1964, when Mr. Charles introduced the Total Package Procurement concept, he referenced the need to compete production and support as well as development in system acquisition. This meant that estimates of the life cycle costs associated with the total program needed to be identified (22:46).

It was not until 1966, however, that serious efforts were begun to develop a methodology to use life cycle costs as a means to competitively procure specific items. The approach was to attempt to determine which contractor's product would have the lowest anticipated life cycle costs as the item accomplished a specified objective. Consequently a specific item might cost more to acquire, but over its lifetime cost less than a lower bid item. The initial application of this approach involved purchase of non-reparable equipment on a price-per-unit-of-service-life basis rather than on the basis of unit price alone. The benefit of this approach would be to motivate contractors to use total life costs rather than merely acquisition

cost to develop better items (33:10-11).

A specific example of the application was the use of lowest total service life costs in the procurement of aircraft tires. Here the criterion was changed to use the number of estimated landings instead of procurement price as a consideration for procurement. The net effect was to reduce the procurement costs initially by approximately \$15 million per year (77:27).

Although the idea or desirability of using total life cycle costs had been espoused for many years, the history of the concept shows that the concept was still not much more than a desirable objective prior to 1966. It had been written about, but little effort had been expended in attempts to determine what actually comprised the total costs of a system, or even a specific item in the system. Initiation of a test program in 1966 designed to procure specific components on the basis of long term benefits versus the short term least cost concept marked the first significant effort to use life cycle costs as a criterion for procurement. The aircraft tire example illustrates this point.

The next major developments in Life Cycle Costing were the release in July 1970 of the Life Cycle Costing Procurement Guide (LCC-1) and Casebook Life Cycle Costing in Equipment Procurement (LCC-2). In fact the procurement guide stated:

"This guide represents the first attempt of the Department of Defense to establish procedures for employing the Life Cycle Costing concept in acquisition of material below the level of complete weapon systems" (46:1-1).

The guide also identified items which should be considered for life cycle costing. These included:

1. Items not subject to repair, for which the anticipated annual buy exceeds \$50,000.
2. Items subject to repair, for which the anticipated annual buy exceeds \$100,000.
3. Standard commercial items.
4. Items having undesirably high failure rates.
5. Items recognized as needing or being susceptible to improved reliability/maintainability (46:1-2).

The Casebook (LCC-2) was designed to be used as an aid in implementing the Life Cycle Costing concept in equipment procurements in all Department of Defense components. The casebook describes and illustrates the application of the concept to competitive procurement of equipment below the level of major systems (20:1). Cases included for study of application of the concept are replacement of siding on family housing, T-38 aircraft tires, computer replacement and others.

In 1973 specific guidance concerning the use of the Life Cycle Costing concept in system acquisition was provided with the publication of the Life Cycle Costing Guide for System Acquisition. This document presents guidelines, including representative detailed

procedures, for applying the Life Cycle Costing concept during the acquisition of complete defense systems. It completed the evolution from LCC-1 and LCC-2 which were concerned with estimating costs of materiel below the level of a complete system.

Later in 1973 Air Force Regulation 800-11, Acquisition Management (Life Cycle Costing), was released. In paragraph 1, the regulation states:

"The Air Force will to the maximum practical extent, determine and consider life cycle cost in various decisions associated with the development, acquisition, and modification of defense systems and subsystems and in the procurement of components and parts" (4:1).

The final evolutionary document which should be identified is the Operating and Support Cost Development Guide for Aircraft Systems. It was prepared by the Cost Analysis Improvement Group and was dated May 1974. It is aimed at specifically improving the Department of Defense capability to quantify operating and support cost impacts of new systems and to consider those cost impacts in the system acquisition process (54:2). It provides a detailed methodology for estimating operating and support costs for aircraft systems. Similar guides for missile systems and other major systems were to be developed.

In this section the writer has identified significant events in the development of Life Cycle Costing as a

concept to be used in acquisition strategies, both for systems and components. There was no attempt to be all inclusive. The dates cited and the documents referenced show that Life Cycle Costing has developed from a vague goal to reduce total costs over a system's lifetime into a comprehensive concept. It is a concept which, if used carefully, can significantly reduce the cost growth associated with ownership of a system.

Definition

The concept of Life Cycle Costing is defined in terms of life cycle costs. Therefore this section will develop a definition for life cycle costs.

The term life cycle cost may be considered to describe the total costs associated with a specific system, component, or item over the evolution of the product from conception to disposal. In this section the writer will review and discuss specific definitions applied to the term to determine if this is the appropriate way to clarify the meaning of the definition of the concept of Life Cycle Costing. These specific definitions are presented in subsequent paragraphs.

The Life Cycle Costing Procurement Guide has defined life cycle cost in the following terms:

"Life cycle cost is an acquisition or procurement technique which considers operating, maintenance, and other costs of ownership as well as acquisition

price, in the award of contracts for hardware and related support. The objective of this technique is to insure that the hardware procured will result in the lowest overall ownership cost to the Government during the life of the hardware" (46:1-1).

In this definition life cycle cost is considered to be a technique used during procurement to ensure the lowest total ownership costs for a piece of equipment are incurred during the life of the equipment.

Air Force Regulation 800-11 has defined the term as follows:

"Life Cycle Cost. The total cost of an item or system over its full life. It includes the cost of development, acquisition, ownership (operation, maintenance, support, etc.) and, where applicable, disposal" (4:1).

This definition identifies what life cycle costs should include when evaluating the cost of a piece of equipment. The intended use of the term was more clearly identified in a subsequent paragraph of the regulation:

"The use of life cycle cost is not intended to make minimum cost the predominant decision factor, but to insure a proper balance between cost and system effectiveness" (4:2).

From this it can be concluded that the use of life cycle cost can be thought of as a philosophy of management. In this view the objective is to obtain an item at the lowest cost consistent with desired system effectiveness.

Another view of the concept itself was stated in a General Accounting Office study of Life Cycle Costing:

"Life Cycle Costing is a technique for estimating the total cost of a product over its useful life, including the expected costs of acquiring the item and its absorption into inventory. The latter are frequently referred to as ownership costs" (44:1).

As before the view in this definition is that the concept should be considered a technique to be used in estimating the total costs of a product.

Finally the Life Cycle Costing Guide for System Acquisition had the following definition for the term life cycle cost:

"Total cost to the government of acquisition and ownership of a system over its full life. It includes the cost of development, acquisition, operation, support and where applicable, disposal" (45:1).

It further added that estimates made at particular times might include only the relevant costs at that time ignoring costs which were the same for all alternatives under consideration.

This writer believes that the concept should be considered as more than a technique to determine the cost of a product. It should be thought of as a philosophy, discipline and tool which can be used to significantly reduce the cost of items procured by the Department of Defense.

The definition offered in the Life Cycle Costing Procurement Guide implicitly supports this view. While it considers life cycle cost as a technique,

it implies that use of the concept is an essential management strategy to reduce acquisition costs. It also implies the need to consider tradeoffs based on life cycle costs during acquisition. The writer, therefore, believes that it is this view of the concept that should be used in defining the concept for application by the manager.

Criteria For Use

In this section criteria for use of the Life Cycle Costing concept will be presented. While the criteria identified in this presentation may be equally applicable to system acquisition and item procurement, the emphasis will be on system acquisition. The items discussed represent a synthesis of findings concerning criteria for application of the concept in acquisition. It is not intended to be all inclusive. It should, however, provide an outline which can be used as a basis for use of the concept. Finally no attempt was made to rank order by importance particular items, because these will vary with the program for which the life cycle costs are estimated.

1. Effective application of Life Cycle Costing requires development of an element structure (33:11). This structure consists of elements or categories where cost must be estimated. This structure should be made up using the "Pareto" principle, which states that approximately 80 per cent of the costs can be found in only approximately 20 per cent of the components comprising the system (26:17).

2. Life cycle costs must be specified for a specific time period (45:2-4). This should be done to ensure that the competitors for the contract use the same time period to determine their estimates. Significant differences could occur otherwise.

3. Cost rules are needed for application of the concept. These cost rules should specify (1) if costs are to be figured in constant or current year dollars, (2) when costs should be counted whether at time incurred, time invoiced to the government, or time paid by the government, (3) rules for discounting future costs with appropriate accompanying tables to maintain consistency and, (4) whether costs should be determined on a fiscal or calendar year basis. These rules typify the type of rules needed to be designated in application of the concept (33:13).

4. A suggested format for estimates should be provided. This ensures that all estimates can be easily compared to determine where the significant differences are in the estimates (33:13).

5. Contractors should use a common model. Normally a model developed by the Air Force should be provided, so that each contractor is using the same factors in his calculations (77:29).

6. Application of the concept should provide for reports on analyses. The contractors should provide periodic reports on their analyses of the life cycle costs. This is important because these reports will be based on additional data which will increase confidence in or validate the earlier estimates (77:29).

7. Proposed modifications should contain an assessment of the life cycle cost impact. This will aid the manager in determining whether or not to proceed with the change (33:13).

8. The estimating models used must be reliable. This means that the estimates generated by the models must correctly portray the projected costs of the system. Inaccurate estimates based on faulty data or incorrect models will yield unsatisfactory information for the decision maker.

The objective in identifying these criteria was to provide the manager with some general considerations

for him to use in applying the Life Cycle Costing concept. The key criterion is sound judgement, however.

Application During the Acquisition Life Cycle

In this section the application of the Life Cycle Costing concept during the acquisition life cycle of a system will be analyzed. This analysis will emphasize the benefits and deficiencies associated with use of the concept in the conceptual, validation, and full-scale development phases of the acquisition life cycle. These phases will be emphasized because it is during these phases that the decisions, which will determine costs in the production and deployment phases, are made.

The first phase where Life Cycle Costing can be used is the conceptual phase. The importance of considering life cycle costs in the early design process was noted in Air Force Regulation 800-11. In paragraph 3a., the regulation states:

"Since ownership cost can be influenced by the type of requirements proposed (design concept)...., it is imperative that consideration of such cost begin in the initial development and design effort" (4:2).

In a 1975 speech the Under Secretary of the Air Force, James Plummer, said: "In the conceptual phase, it (life cycle costs) will help us to select among alternatives" (60:29). During this phase the concept

also aids in assessing which designs are the most cost effective ones and merit further attention in the validation phase. Life cycle cost estimates also can provide baseline estimates for tradeoff analyses in the validation phase. However, there are significant deficiencies associated with these early estimates.

One deficiency, which is common to all phases, is that life cycle cost estimates are only as good as the assumptions, theories, relationship between parameters, and the data used (whether assumed or historical) (69:5). Consequently there may be too many unknowns in the early stages of the acquisition life cycle to ensure a high degree of confidence in the estimates or models used to make the estimates. Additionally, the dynamic tendencies of design changes may minimize the accuracy of the early estimates. However, the early estimates do provide a guideline to use when the system moves into the validation phase.

In the validation phase there should be increasing confidence in the estimates. This is especially true if there are prototypes built to assist in determining which design to produce, because more data are available with which to project costs. In this phase life cycle cost estimates can be decisive in tradeoff analyses to find the most cost effective alternative. Also as Mr. Plummer has indicated:

"In the validation phase, it (life cycle costs) will help us verify our concept...it will be a factor in source selection" (60:29).

In the validation phase there is still a requirement to use models to project costs. Consequently the same problem with cost estimates that occurred in the conceptual phase remains in the validation phase.

Life Cycle Costing loses some effectiveness as an acquisition tool, as a program enters the full-scale development phase. The design is specified in greater detail and less opportunity for tradeoffs exist. However, life cycle cost estimates can still be a significant factor in determining maintenance policies and procedures. Additionally in this phase the validity of the earlier estimates and the techniques used to make those estimates can be determined. One result will be increased confidence in later acquisitions, which may use the same or similar techniques. Identification of life cycle costs also provides information for use in determining what systems or changes to improve the cost effectiveness of systems should be considered in future acquisitions.

The Life Cycle Costing concept also has significant importance in the production and deployment phases of the acquisition life cycle. In the production and deployment phases one objective is to obtain the data required to determine the validity of earlier estimates,

which will improve future life cycle cost estimating capabilities. Another objective is to use the data as a baseline for determining how to design future systems to improve cost effectiveness.

In this section the application of the Life Cycle Costing concept during the acquisition life cycle has been examined. It has been shown that life cycle cost estimates in the early phases aid in decisions concerning design choices and source selection based on projected cost effectiveness. It should be remembered that estimates made early in the acquisition process should be considered only as general aids to the decision maker, because these estimates can only provide a general projection of costs for different alternatives. It has also been shown that life cycle cost estimates have a different application as a system goes into production and deployment. In these phases the technique is used primarily to collect data, which will be used to improve future life cycle cost capabilities.

Strengths

In this section strengths of the Life Cycle Costing concept will be identified. The items identified in this section represent a synthesis of the common favorable traits of the concept. Their specification should provide the manager with a clearer understanding of what Life Cycle Costing can do to aid him. Likewise,

the weaknesses presented in the next section will specify where the problems are in using the concept. There has been no attempt to rank order the items, because the importance of a particular item will vary with the program and with what phase of the acquisition life cycle the program is in.

Determination of life cycle costs provides an identification of the total costs of a program. The concept aids in knowing what the development, acquisition, operation, support, and disposal costs are at any stage in the acquisition life cycle. The other strengths of the concept are derived from this fact.

A second strength of Life Cycle Costing is the elimination of undesirable suboptimization (76:56). Suboptimization is a term which in this case means selection of a particular option based on the short term benefit and not the long term effect. Identification of total costs enables the manager to see the best estimate of possible long term effects of a decision now. This should cause him to carefully evaluate his alternatives before he selects one. Figure 4 graphically illustrates how the least cost option in the beginning could be the highest cost option in the out year cost growth picture. In figure 4 option A initially has a considerably faster rate of cost growth, but it rapidly decreases as usage of the system increases. Option B has a fairly steady cost growth. The result

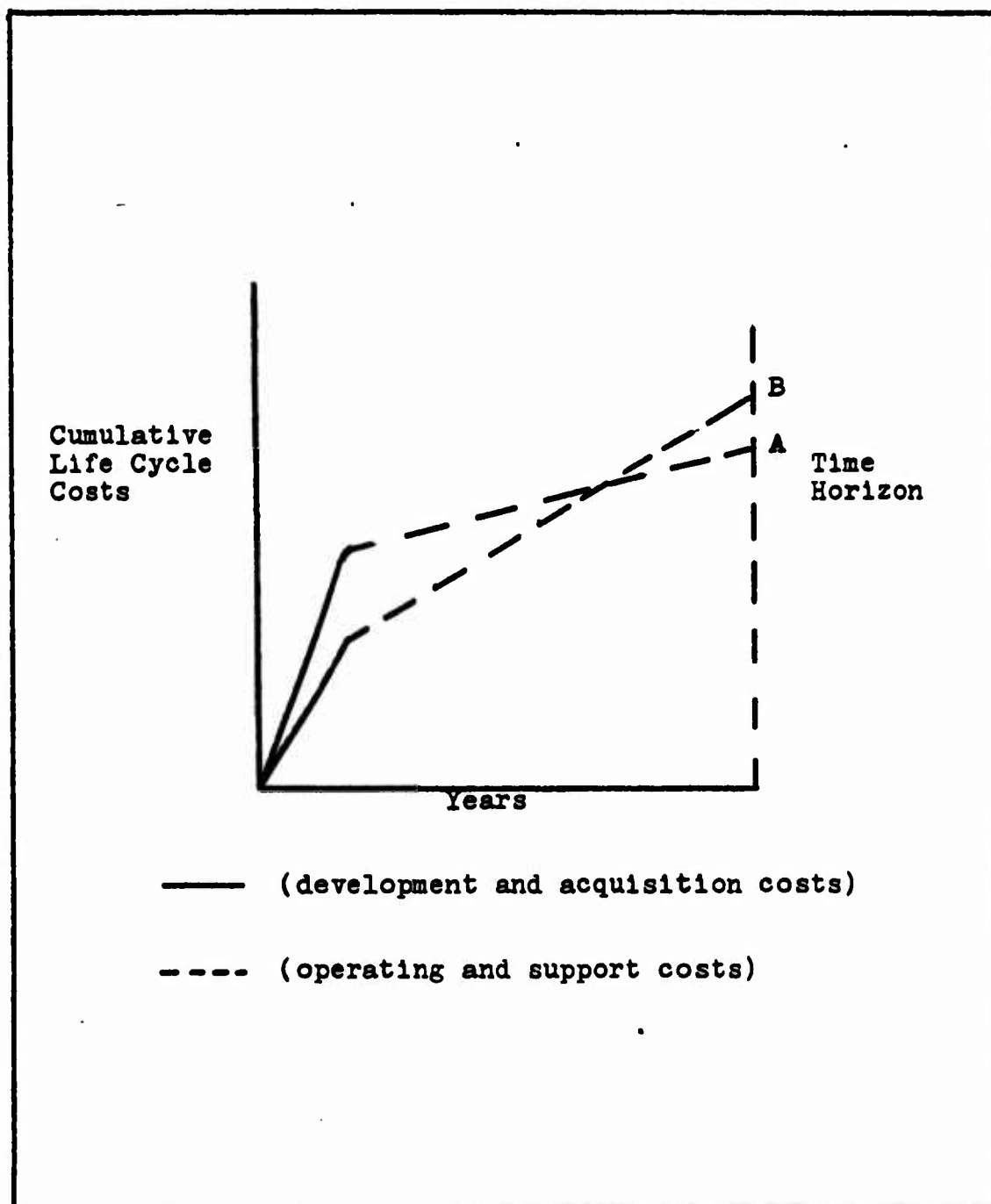


Fig. 4. Comparison of Life Cycle Costs Over Time

is that at some future time the accumulated costs make option A the more cost effective option (45:2-3). Early identification of this trend can help the manager in his assessment of options.

A third benefit of Life Cycle Costing is that it forces the planner to face the hard realities of total cost. Knowledge of the total cost effects can aid the decision maker in deciding whether to proceed with a program or stop it early enough to reduce costs. Knowledge of total costs and budget impacts partially account for the next strengths (44:2).

Use of the Life Cycle Costing concept can lead to improvements in reliability and maintainability. Comments by Mr. Robert Seamans, former Secretary of the Air Force, highlight this point:

"The real expense of owning any system is a combination of its development, production, operations, and maintenance costs. If we can build more reliability and cheaper maintainability into a system, we can significantly reduce its total life cycle costs" (70:48).

In the same article Mr. Seamans cited a specific example. The Minuteman III guidance system was designed with a specification to operate continuously for 300,000 hours. The contractor more than doubled this figure in operational use. The effect was a savings of approximately \$78 million in reduced maintenance and spare part costs. The contractor, of course, benefited

in the incentive fee he won, but the Air Force benefited even more (70:51).

Use of life cycle cost estimates can encourage broad tradeoff studies. These studies will aid in providing tradeoff flexibility. In situations where several options are available, determination of the expected total costs of each option can be decisive in the selection of a specific option (67:19). Knowledge by the competing contractors that life cycle cost estimates will be a factor in selection can cause the contractors to consider the life cycle costs, as well as, acquisition costs in their designs and tradeoff analyses.

Life Cycle Costing can cause a reduction in cost growth. The guidance system example illustrates this point. Operating and support costs were reduced substantially as a result of the improved reliability.

Finally Life Cycle Costing can be a basis for future system development. Knowledge of the life cycle costs provides an improved visibility of the factors or systems which contribute to costs. Secretary Plummer noted in a speech that 8 of approximately 300 subsystems on the F-16 aircraft represented almost one half of the 15 year subsystem logistics costs (60:29). This type of knowledge can aid the planner in considering what areas to emphasize in planning future systems to reduce costs. He can emphasize the significant few

Identification of Total Costs

Elimination of Undesirable
Suboptimization

Consideration of the Realities
of Total Cost

Improvement in Reliability
and Maintainability

Reduction in Cost Growth

Basis for Future System Development

Fig. 5. Summary of Life Cycle Costing Strengths

OSM/SM/705-5

in his planning efforts.

These items highlight the strengths of the Life Cycle Costing concept. They are summarized in Figure 5. These points show that knowledge of total costs can have a significant effect. They also show that emphasis on reductions in total costs through improvements, such as reliability, can significantly reduce costs. Weaknesses associated with use of the Life Cycle Costing concept will be examined in the next section.

Weaknesses

The weaknesses of the Life Cycle Costing concept present formidable challenges to the manager. While the effects of successful application of the concept are impressive, the difficulties in achieving those successes are significant. In this section a synthesis of the most common and important weaknesses associated with the concept will be analyzed. There will be no attempt to rank order the weaknesses by importance.

The reliability of the data used in life cycle cost estimates presents a major weakness. There is a question of whether data from an in-use system is relevant for use in determining potential costs of a new system. This is because the new system may be used differently or in a different environment from the one which is providing the data for the estimate (67:17). The use of historical data also requires assumptions

on how the operating and support costs were determined for the older system. Finally there is the difficulty of verifying that the cost factors used in the estimate are the same as those used in the historical data bases.

Closely related to the data reliability problem is one concerning data collection systems. In a recent Government Accounting Office report it was noted that a great obstacle to Life Cycle Costing was the absence of a data base segregating total ownership costs by weapon. It noted that the practice had been to accumulate operating costs by organization or classes of weapons rather than by individual weapon systems (44,5).

The same report offered one method to eliminate this problem. The suggested approach would be sampling. In this approach a specific quantity of vehicles would be selected and the costs accumulated on them for a specific time period. Thus costs could be separated at the point of origin without changing the total collection system (44,6).

Another major weakness of Life Cycle Costing is the complexity of the concept. The recent Operating and Support Cost Development Guide for Aircraft Systems identifies at least 15 major areas where costs must be obtained to determine total operating and support costs. Areas identified included such items as combat command staff manpower, aircraft security manpower,

aviation fuel, base services manpower, recurring investment and others (54:8). This guide is directed only toward the operating and support costs of the system. This illustrates the complexity of the concept, when one remembers that broad areas of cost factors must also be added from development and production to determine total costs. Another factor causing complexity is designation of a specific lifespan for a system. Estimates are based on a system having a specified useful life. If the system's projected lifespan is changed the costs associated with the system change (76:37). Finally the concept is based on assumptions, theory, empirical relationships, and data, which may or may not be valid. All of these factors combine to make the concept very complex.

The concept may be too vague for effective implementation. A General Accounting Office report indicated that there appeared to be "...lack of guidelines on costs to be included in an ownership estimate" (44:11). Mr. John Bennett, Acting Assistant Secretary of Defense (Installations and Logistics), has commented that "Refinement of terms, conditions, requirements, and data validity and availability is badly needed" (11:3).

Another weakness to successful use of Life Cycle Costing is institutional bias. Life Cycle Costing requires that the manager and planner consider the

long term cost effects of changes in systems. The past attitude has been to look only at the short term effects. There is also the normal reluctance to change to a new way, especially when there are many questionable areas in the new approach. This causes a lack of confidence in the estimates. The net effect is to make the manager hesitant to rely on the estimates generated by life cycle cost models (44,9-10).

The final significant weakness with Life Cycle Costing is the budgetary process. Budgets are oriented toward short term funding. The emphasis is to save money now. Consequently, it is difficult for the manager to justify increased expenditures today to save substantial funds in the distant future. This is true, especially, when the expenditure is based on an estimate in which there is little confidence. Additionally there could be reluctance to provide the additional funds to even make the cost estimates.

All of these weaknesses tend to reduce the effectiveness of Life Cycle Costing. The weaknesses are summarized in Figure 6. However, it has been demonstrated by the savings achieved in the aircraft tire and guidance system examples that the concept can work. It can reduce expenditures and provide better systems. The challenge remains for the manager to use the concept with the knowledge that the key to its effectiveness is the manager's judgement in

Data Reliability and Collection
System

Complexity of the Concept

Vagueness of the Concept

Institutional Bias Against Change

The Budgetary Process

Fig. 6. Summary of Life Cycle Costing Weaknesses

application of the results of a life cycle cost estimate. The final point to remember is "...at most a life cycle cost estimate may represent the best estimate at a given point in time" (44,14). It is in this light that the concept should be used in the acquisition of new systems.

In previous chapters the concepts of Total Package Procurement and Life Cycle Costing have been analyzed. The third concept which was developed to control the costs of weapon systems from initial conceptual identification through the system's lifespan was Design to Cost. This concept has generated much discussion, as it represents a definitive departure from the previous acquisition philosophy, where performance was the prime consideration in system acquisition.

Historical Evolution

Review of the history of Design to Cost indicates that the concept was developed primarily by former Deputy Secretary of Defense, David Packard, and the former Director of Defense Research and Engineering (DDR&E), Dr. John Foster. One writer in tracing the history of the concept first found reference to it in Department of Defense literature of June 1969, which was shortly after Secretary Packard assumed his position (48:3). The first public reference to the concept was made by Dr. Foster on 12 March 1970 in remarks to the National Security Industrial Association. In that speech he said "...price has as much priority as performance." "...we must design-to-a-price,..., or else we will not be able to afford what we need" (48:3).

In early May 1970 the Request for Proposal was issued for the A-10 (formerly A-X) aircraft. The A-10 is a simple low-cost system designed specifically to perform the close air support mission. The Request for Proposal included a specification that the aircraft be produced for approximately \$1.4 million in average unit flyaway cost. This represented the first effort by the Department of Defense to levy a strict "design-to" requirement on the acquisition of a weapon system.

On 28 May 1970 former Secretary Packard issued a memorandum titled "Policy Guidance on Major Weapon System Acquisition". In that memorandum he wrote:

"The cost of developing and acquiring new weapon systems is more dependent upon making practical tradeoffs between the stated operating requirements and engineering design than upon any other factor. This must be the key consideration at every step in development from the conceptual stage until the new weapon goes into the force" (56).

The next major reference to Design to Cost was in Department of Defense Directive 5000.1, which is dated 13 July 1971. This directive was signed by Mr. Packard. It stated in one paragraph that "...cost elements...shall be translated into "design to" requirements" (57:4). This then formally identified the concept as being relevant and required for system acquisition. The directive and, in particular, the paragraph from which the above reference is taken will be discussed in detail in the definition section of

this chapter, It was with the issuance of this directive that the concept of designing to a specific cost goal was promulgated.

During the period from issuance of the directive until June 1973 the primary emphasis appeared to be in explaining what the concept was, how it should be used, and when it should be used. The prevalent view during this period was presented by Dr. Foster in a speech in October of 1972. During that speech he said:

"...we must change the objectives of the research and development community from the overriding emphasis on improving the state of the art in performance, to an emphasis on quality equipment having an acceptable performance for an affordable cost" (48:29).

On 18 June 1973 the next major commitment to the Design to Cost concept was made by the Department of Defense. On that date Deputy Secretary of Defense Clements issued a memorandum titled "Design to a Cost Objectives on DSARC Programs". In the memorandum he directed that a Design to Cost goal be applied to all major DSARC programs. He further stipulated that the goal would be the average unit "flyaway" cost of the product. In the memorandum he also wrote:

"For future programs, a "Design to a Cost" estimate will be established at the earliest possible date, but not later than the entry into the full-scale development phase of the acquisition process."

He also wrote:

"It is the intent that in the future all new major programs will have established Design to a Cost goals" (23).

At this point the concept moved from being a goal to attain as identified in Directive 5000.1 to being a requirement for all major programs in the acquisition process.

In October 1973 two documents were released which formed the how to use methodology for Design to Cost. The first was the Joint Design to Cost Guide (AFSC Pamphlet 800-19) (41). This guide is dated 3 October 1973. Its purpose was to provide guidance and assistance in the implementation of the Design to Cost concept. Its basic intent was to identify what should be done with a general approach of how to do it.

The second document was the Cost To Produce Handbook, which is dated 26 October 1973 (26). Its purpose was to (1) explain the need and intent of Department of Defense policies on Design to Cost, (2) discuss various concepts and practices which currently appear useful in the application of Design to Cost to systems, equipment and material, and (3) illustrate application of Design to Cost by inclusion of approaches in programs using Design to Cost. It also reiterates the importance of the need to control costs when it states:

"The reduction of cost overruns and the arresting of unit production and support cost growth are essential (1) to retain the confidence of Congress in allocating funds for national defense, and (2) to provide the most effective defense establishment within the budget authorized the Department of Defense" (26:6).

Further refinement of the concept occurred in 1974. Up to that time Design to Cost was oriented toward major programs or systems application. The Packard memorandum of 1970 referred to system application. The Department of Defense Directive 5000.1 referred to system application. The Clements memorandum of 1973 referred to major program application. Although the Cost to Produce Handbook refers to using the concept for "...many other items as well" (26:5), little effort was made to apply the concept to subsystems or less than major programs. In May 1974 Secretary Clements issued a memorandum clarifying this point. This memorandum extended the requirement to use the Design to Cost concept to subsystems and the less than major defense systems (82:4).

In the January 1976 issue of the Defense Management Journal, Mr. John Bennett, Acting Assistant Secretary of Defense (Installations and Logistics) commented on Department of Defense Directive 5000.28, which was issued in mid 1975. This directive explicitly emphasizes management of weapon systems to ensure establishment of "costs as a parameter equal in importance with

technical requirements and schedule." The directive also defines Design to Cost as a philosophy and goal (11:1).

Recently Secretary Clements issued another memorandum, which requested that each service establish operating and support cost targets for each system in development (29:14).

In this section the writer has chronologically identified the key points in the evolution of the Design to Cost concept. The specific comments and documents which were referenced represent the significant events in the development of this concept as a cornerstone in recent Department of Defense strategy to impose controls over the increasing costs associated with the acquisition of new defense systems. Many other reports, speeches, articles, and comments could have been added, but the ones used here establish the flow and development of the concept into a major acquisition approach of the mid 1970's.

Definition

In this section the definitional evolution of the Design to Cost concept will be examined. The specification of a single definition for the concept has been difficult. This occurred because Directive 5000.1 indicated that the concept applied to acquisition, operating and support costs, but early writings and

directions appeared to be oriented toward acquisition only. Consequently, attempts to establish a precise definition for the concept have proven to be perplexing. However, this writer's research has established that the original intent, as identified in Directive 5000.1, is the appropriate way to define Design to Cost. Several definitions of the concept will now be presented to illustrate the development of the concept. These definitions follow a chronological evolution.

Air Force Regulation 800-9, Acquisition Management Production Management in the Acquisition Life Cycle, dated 25 April 1973, has defined the concept of Design to Cost as:

"...(a) the unit production cost goal or (b) the unit production cost ceiling in selected programs based on a specific quantity and rate of production, which is used as a design criteria to control costs during design/development" (3,atch 1).

The Joint Design to Cost Guide, dated 3 October 1973, has defined the concept in the following terms:

"Design-to-Cost is a process utilizing unit cost goals as thresholds for managers and as design parameters for engineers. A single cumulative "Average Unit Flyaway Cost" goal is approved by DSARC for the program... The dollar value for each goal represents what the government has established as an amount it can afford (i.e., is willing and able) to pay for a unit of military equipment or major subsystem which meets established and measurable performance requirements at specified production quantity and rate during a specified period of time" (41,4).

The Cost to Produce Handbook, dated 26 October 1973, has defined Design to Cost as meaning:

"...the feedback and the control of future production, operating and support costs during the design and development process" (26:1).

Mr. George Sutherland, the Assistant Director (Systems Acquisition Management) in DDR&E, defined the concept in September 1974 in the following way:

"...the term "design to cost" means the management and control of future acquisition, operating and support costs during the design and development process under established and approved cost objectives" (36:2).

In December of 1974 Mr. Sutherland defined the concept in the following terms:

"The establishment of cost goals early in the development process and the management and control of future acquisition, operating and support costs to these goals by the conduct of practical tradeoffs between system capabilities, cost and schedule" (82:5).

In January of 1976 Mr. Bennett in a review of the Department of Defense Directive 5000.28 definition of Design to Cost wrote:

"As a philosophy Design to Cost means the control of system acquisition, operating and support costs; example - managing the life cycle cost. As a quantitative contractual goal, Design to Cost in general practice is defined as the average unit flyaway cost with visibility maintained in parallel with the total life cycle cost" (11:1).

These "definitions" for Design to Cost have been quoted to show that the concept has meant many things. It has been interpreted as a philosophy, a goal, a ceiling, a process, and a mechanism for management and control. It is all of these things. The reasons for these varied definitions of the concept are perhaps best explained in a statement made by Mr. Arthur Mendolia, former Assistant Secretary of Defense (Installations and Logistics), to a Committee of Congress:

"The objective of this approach is to induce designers to be cost conscious so that they will make tradeoff decisions based on cost versus performance."

He added further that Design to Cost meant the establishment "... of predetermined cost ceilings...to meet goals." Finally he said:

"In addition to providing flexibility in choosing levels of quality and performance in the design phase, it is also intended to provide tradeoffs on production schedules in the manufacturing phase" (82:2).

In all of these definitions the common theme of controlling cost is prevalent. Whether it is acquisition costs or operating and support costs, the thrust of Design to Cost is to restrain cost growth. Establishment of a not greater than goal by the government early in development forces the contractor and the program

manager to work harder to produce the system at a lower price. Likewise, emphasizing the need to reduce out year operating and support costs when the system is still in design forces the contractor and program manager to consider this area more in the early development, when tradeoffs to reduce costs can most easily be made. It has been estimated by many experts that approximately 80 per cent of a system's total cost is in operation and support, so early tradeoffs can greatly affect these later costs.

The question of a definitive definition for Design to Cost still remains open, however. This writer believes based on his research that the definition of the concept has never been in doubt at the highest levels in the Department of Defense. Design to Cost means the same today, as when Mr. Packard first identified it as a basic requirement in Directive 5000.1. The problem then, as it remains today, is one of accurate estimation of what costs will be for a system, as it completes development and goes into production and deployment.

A clearer understanding of why accurate cost estimation is a problem is provided in the following discussion. First the pertinent paragraph from Directive 5000.1 will be quoted, then the comments made by Mr. Sutherland in his tracing of the evolution of the concept will be reviewed.

Paragraph III C.2. in Department of Defense

Directive 5000.1 states:

"Cost parameters shall be established which consider the cost of acquisition and ownership; discrete cost elements (e.g., unit production cost, operating and support cost) shall be translated into "design to" requirements. System development shall be continuously evaluated against these requirements with the same rigor as that applied to technical requirements. Practical tradeoffs shall be made between system capability, cost and schedule. Traceability of estimates and costing factors, including those for economic escalation, shall be maintained" (57:4).

The key points to remember in the paragraph are (1) cost parameters will consider both acquisition and ownership costs, and (2) discrete (distinct and separate) cost elements will be translated into design to requirements. This means that both a per unit production cost goal, as an example \$1.4 million per unit, and an operating and support cost goal, as an example \$1.5 billion for the system per year, should be established during the early development of the system. This commitment to include operating and support cost goals was emphasized by Mr. Bennett in his comments on Directive 5000.28 (11:1). Earlier Mr. Sutherland was stressing the same point.

Mr. Sutherland in reviewing the evolution of the Design to Cost concept in the Department of Defense specifically highlighted the point that in Directive 5000.1 the "design to" requirement was meant to include

total life cycle costs. However, it was apparent, when Design to Cost was first introduced, that reasonable operating and support cost estimates could not be specified during the design period. As the discussion on life cycle costs pointed out, data collection systems were not set up to collect cost data on individual systems, so accurate estimates, when attempting to project costs of a new system based on comparison with an older system were virtually impossible. Consequently the early Design to Cost goals were established on production costs. In specific terms this meant as Secretary Clements' memorandum of June 1973 spelled out - Design to Cost would be the average unit "flyaway" cost for a system. The following comment by Mr. Sutherland illustrates this point:

"It was fully appreciated that Design to Cost at this point was quantitatively addressing only the production costs with operating and support costs, usually much larger, being considered more indirectly" (82:3).

Use of the concept to estimate production costs and greater confidence in life cycle cost estimating models has permitted a start toward implementing the objective of establishing a goal for operating and support costs in the early developmental phases. This confidence apparently resulted in the recent memorandum by Secretary Clements requesting that each

for each system in development (29:14). This means that today the Design to Cost concept is moving toward implementation of the original objective stated in Directive 5000.1 to establish discrete cost estimates for all cost elements, which can be translated into distinct parts.

It is, therefore, concluded that the definition of Design to Cost both as a philosophy and goal is the one that should be used in applying the concept in the future. To reiterate, Design to Cost means to control acquisition, operating and support costs. It also means to establish quantitative cost goals for the system or subsystem to which Design to Cost is applied. This means an average unit "flyaway" cost goal and an average operating and support cost goal. Both of these goals would be established as early as possible in the acquisition life cycle.

Criteria For Use

Now that the historical and definitional evolution of the concept has been developed, it is appropriate to consider the criteria under which Design to Cost should be applied. This section will present a synthesis of findings concerning application of the concept to earlier programs. It is intended to provide a frame of reference to use in determining how to or

provide a checklist or cookbook of groundrules for use of Design to Cost. Individual judgement and common sense still are the primary criteria for successful management, because all programs and situations have subtle differences, which will not permit a forced application of remedies. However, a general set of criteria will assist in utilizing good judgement in the acquisition life cycle.

The following list highlights those items that should be considered in applying Design to Cost. The order of the items is not intended to attempt to rank order by importance particular considerations, because these will vary with the program to which the Design to Cost concept is being applied. Nor has the writer attempted to include all criteria, which may merit consideration, but only to identify a sufficient number to provide the manager with a framework within which he can develop those specific criteria required for his individual program.

1. Design to Cost should be applied to programs which have low technological risk and do not attempt to advance the present state of the art (48,10). This is because where advances are attempted into unknown areas it is virtually impossible to determine or estimate costs or even to know all the elements needed to identify a cost goal (38,86).

2. Design to Cost goals should be established as early as possible in the development process to permit meaningful tradeoffs to achieve cost

objectives. This identifies to the designers what the overall goal is early enough, so that as they design they know what they must strive to attain in terms of cost constraints (26:35).

3. The Design to Cost goal should be a point goal rather than a band goal. Establishing a goal of between \$1.5 and 2.1 million is not sufficient to emphasize the need to strictly maintain a cost conscious approach toward reducing cost growth. Knowing the constraint is \$1.5 million will make the designers more conscious of the need to look for tradeoffs (41:14).

4. The number of specified performance parameters should be minimized in Design to Cost. Additionally they should be rank ordered in priority, if possible. This gives the contractor maximum flexibility in tradeoffs to achieve the cost goal (13:2).

5. Design to Cost should require that adequate time and sufficient funds are available during development to permit examination of tradeoffs and alternate design approaches (36:5). Constraining either may cause suboptimization. This is selection of the best short term solution to maintain schedules or budgets, but not necessarily the best long term solution in terms of performance and/or minimum life cycle costs (76:56).

6. Specific definition of what should be included in the Design to Cost goal is critical from a contractual view. For example, changing from government furnished aerospace equipment to contractor furnished aerospace equipment could significantly alter the original cost objective (26:35).

7. Success of Design to Cost may depend on a lack of specification in the Request for Proposal (RFP) (18:31). For example, possible procurement of a new radio is illustrated. If the Department of Defense so desired, it could cite approximately 450 documents in telling the contractor how to produce radios. This amount of detail, if included in the RFP, would effectively stifle contractor flexibility in manufacturing a radio to the design to goal. RFP's should specify only those items absolutely mandatory for the system (18:34).

used to establish the goal. In fact the best approach might be to include various rates and total quantities to cover the situation where things do not go as planned. Programs rarely have matched planned schedules or quantities (26:35).

9. The cost goal should be stable. The goal should be changed only when it is necessary due to a change in requirements, or it is determined that the original goal was not realistic (12:27).

10. Cost objectives should be realistic. The goal should reflect the best available estimate based on available data. It should not be too high or too low. If too high there is no real attempt to obtain the item at the least cost. By the same token if too low it will prove impossible to attain the goal (9:6-7).

11. A successful Design to Cost program should ensure that contractor competition be maintained for as long as it can be realistically justified.

12. The Design to Cost program should emphasize the method to track costs. This will permit a periodic determination that the system can still be produced within the preestablished goal. It also provides a methodology to spot problem areas early enough to take corrective action. It also provides a historical record of what happened during the process (41:22, 26-27).

13. Design to Cost should not be generally used where it is in the national interest not to include a cost specification, or where a very few units are to be produced. However, this does not mean that it cannot be applied to subsystems or components of the system under development. The B-1 aircraft program is an example where no Design to Cost goal is applied to the total system, but it has been applied to several subsystems (9:4).

14. The cost goal should be expressed in specific constant year dollars. This provides a baseline to measure costs against, even with inflation affecting the value of future year dollars. A means must, however, be included in the program to measure the program against the original dollar figure (41:18).

manager needs maximum flexibility. He must have the authority to make trade-off decisions without a rigorous through channels exercise. However, the amount of such authority must also be limited so that mandatory performance, cost, and schedule requirements are not traded off without a review (26:24).

It has not been the intent to compile an all inclusive set of criteria. The intent was to provide a basis for intelligent development and application of the ideas presented for successful management in a Design to Cost environment. The objectives were to (1) identify key considerations which can be applied with careful selectivity and variation of intensity, depending upon the scope and characteristics of the specific program, and (2) recognize that a particular approach should be "tailor made" for application to each individual situation (36:5).

Application During the Acquisition Life Cycle

In this section the writer will review the material concerning at what point in the acquisition life cycle the Design to Cost goal is to be established.

There are five phases in the acquisition life cycle. These are the conceptual, validation, full-scale development, production and deployment phases. Earlier the definitions of the conceptual, validation, and full-scale development phases were given as taken from Air Force Regulation 800-2, Acquisition Management

Program Management. The definitions for the conceptual and validation phases are restated now. These were:

"Conceptual Phase - Initial period when the technical, military, and economic bases for acquisition programs are established through comprehensive studies and experimental hardware development and evaluation."

"Validation Phase - Period when major program characteristics are refined through extensive study and analysis, hardware development, test and evaluations. The objective is to validate the choice of alternatives and to provide the basis for determining whether or not to proceed into full-scale development."

Figure 7 highlights the important points of these definitions. It also shows where the DSARC I and II Reviews occur.

It should be noted that the Request For Proposal for the A-10, which called for a specific unit flyaway cost, was issued with a requirement for prototypes and fly-off competition between two contractors. This means that under current definitions associated with acquisition that the goal could be interpreted to have been established at DSARC I and prior to entry into the validation phase.

The idea of early establishment of the Design to Cost goal was highlighted in Secretary Clements' memorandum of June 1973:

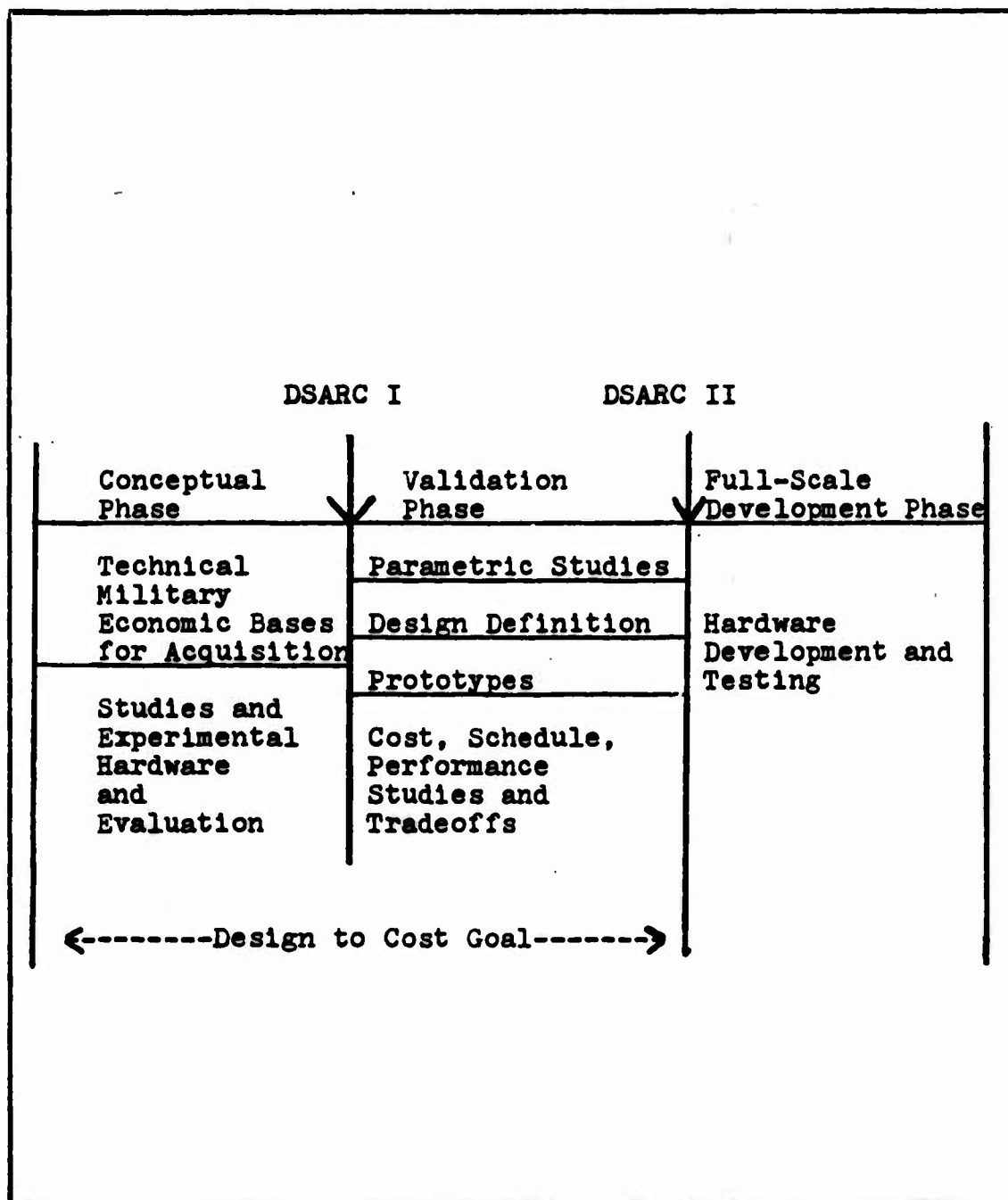


Fig. 7. Design to Cost in the Acquisition Life Cycle

"For future programs, a "design to a cost" estimate will be established at the earliest possible date, but not later than the entry into the full-scale development phase of the acquisition process" (23).

The explicit guidance is contained in Air Force Regulation 800-2, attachment 5, which is Department of Defense Directive 5000.26. That directive specifies that valid Design to Cost goals be established by DSARC II. As is seen in Figure 7, this is at the completion of the validation phase and prior to entry into the full-scale development phase of the acquisition life cycle.

The specification that the cost goal be established no later than completion of the validation phase is logical. Because as Figure 7 shows, it is during the validation phase that the crucial decisions are made concerning the ultimate configuration of the system in development. It is also logical that the goal be established before the start of the validation phase, because it provides a baseline to work against in the tradeoff decisions, which occur during validation.

Strengths

In this section the most significant strengths associated with Design to Cost will be presented. As in the criteria section there will be no attempt to rank order in importance the various items.

The first significant strength is that Design

to Cost causes the designers and the production engineers to take a design/production team approach during the design process. This means that the final design is one that is compatible with what production can produce without extensive modification of production facilities. The net effect is reduced costs. This approach represents a significant departure from the past when designers would design a product, and then the production engineers would have to figure out a way to build it. The A-10 effort by Fairchild incorporated the design/production team approach and produced its prototype in a configuration very close to the production model (38,42-43). This team approach can influence the next strength of Design to Cost.

The second strength is that Design to Cost may provide easier maintainability through simplicity of design. Having to meet definitive cost goals will cause the designer to look for the simpler design, which reduces production costs, but which may also reduce maintenance time and cost in field operation. There are several examples to illustrate this point, but again the A-10 provides a good one. Many parts of the aircraft were designed to be interchangeable or easily removed and replaced. These included engines, parts of the wings, and tail assemblies. While most of this effort was oriented toward a reduction in production costs, it can also result in

reduced field maintenance time and costs. Additionally, with interchangeable components the number of spares can be reduced. It should be noted that simplicity could just as easily increase costs.

The third strength of Design to Cost is that it causes better definition of performance requirements. This does not mean that more requirements are specified. It does mean that the requirements, which are identified, are the crucial ones for the system. For example, the only crucial specification levied for the design of the Advanced Medium Short Takeoff and Landing Transport (AMST) was cargo compartment size (47:50). This example also illustrates the fourth strength of Design to Cost, which is tradeoff flexibility.

Tradeoff flexibility results from a minimization of performance requirements or specifications. By identifying specifications in minimum terms of performance, the contractor is provided leverage to make cost effective tradeoffs. Formerly, the contractor might be told what kind of metal to use, how thick it was to be, how many weld points it was to contain, and many more requirements. But now by having only the general specifications, the contractor can make the decisions, which provide a system that meets the requirements and the designated price.

The next strength of the concept is that the tradeoffs can result in reduced operating and support

costs. Flexibility in tradeoffs and the simplified systems obtained as a result of the team approach can result in a system, which is easier to maintain in the field. Examples on the A-10 include many identical right-left parts on the aircraft, such as built-up engines, vertical tail, main landing gear and stabilizer ribs. These design features were incorporated to reduce production costs, but they will increase field reliability and reduce the number of spare parts needed in the system. This could result in substantial savings over the life of the system.

Another strength of having a designated cost objective is that it provides strong motivation to restrain cost growth. Managers are reluctant to have to justify cost increases without good reasons. Likewise, contractors with incentives based on a specific cost goal will be hesitant to break through a cost ceiling knowing that it will cost them in profits.

An additional strength of Design to Cost is that it can provide an early idea as to whether or not cost objectives will be met. When a manager is working with a constrained budget, or production is based on projected cost, it is important to know early in the process if the designated goal can be achieved. Design to Cost can do this, because it tracks the total system costs and can detect early in the program

unsatisfactory trends (41:22, 26-27).

Another strength of Design to Cost is that it can lead to more standardized components. An example is the engine for the A-10. The engine was originally developed for a Navy aircraft. It was determined that it could fulfill the A-10 requirements, so it was used (38:53). This was accomplished with substantial savings. The idea of standardized components has potential for significantly reducing costs.

Finally Design to Cost gives the program manager greater flexibility. He has greater latitude in what decisions he can make. This increases tradeoff flexibility during the crucial developmental decisions that can to a great extent determine if a program will meet its cost objective.

These are only some of the strengths of Design to Cost. They are summarized in Figure 8. These, however, highlight the potential that the concept has in the acquisition process. In the next section some of the significant weaknesses of Design to Cost will be presented.

Weaknesses

In this section weaknesses of the Design to Cost concept will be examined. The specific items represent a synthesis of this writer's research. The weaknesses have been determined to be the ones most commonly

Integrated Design Team Approach

Maintainability Improvement

Better Definition of Performance Requirements

Greater Tradeoff Flexibility

Reduced Operating and Support Costs

Reduced Cost Growth

Early Information on Cost Goal Attainment

More Standardized Components

Greater Program Manager Flexibility

Fig. 8. Summary of Design to Cost Strengths

identified in the literature and in lessons learned concerning the concept. As before, there will be no attempt to rank order by importance the specific items. It should also be noted that not all supposed weaknesses will be identified, only the ones which seem to represent the type which the program manager could expect to encounter in most situations.

One of the most important characteristics of Design to Cost is the requirement for the establishment of a cost goal as early as possible in the development process. This by its nature represents a significant weakness of the concept (50:27). The early activities associated with the development of new systems are very dynamic. Tradeoffs are made. Test results may change the direction of the development. Reassessment of the threat may alter program direction. Environmental restrictions could alter the development of the system. Planned production rates may change in response to the results of initial tests. All of these items could drastically affect a goal based on a paper assessment.

It is realized that the key to the success of the Design to Cost concept is the early determination of a specific cost goal. However, as this discussion has shown, it may be extremely difficult to maintain a goal established so early in development. So, one of the cornerstones of Design to Cost, itself,

represents a significant weakness of the concept.

Design to Cost may stifle innovation and restrict the use of new technology (9:12). While an argument can be made for the opposite viewpoint, as well, it seems logical that the contractor with a specified cost goal will tend to use what he knows will work, rather than try a new approach, which may reduce costs but involves risk.

Successful implementation of Design to Cost requires a situation with maximum flexibility. This implies a need for a flexible environment, where many tradeoffs are available (76:38). With few tradeoff possibilities the contractor's flexibility in making changes which satisfy performance requirements and also reduce costs are limited.

Design to Cost could cause suboptimization. The short term goal of meeting a specific cost ceiling may cause decisions which neglect long term cost effects (76:56). This deficiency has been recognized, as most writers stress the need to consider out year costs as well as the near term costs. However, when budget dollars and schedules are constrained, it is easy to ignore potential deficiencies, because they will not be a problem for several budget periods, and then they will be someone else's problem.

There is the normal institutional bias against change (48:25). Part of this bias results from the

belief that the approach in the Department of Defense should be performance first at any cost. Mr. Sutherland and Mr. Jacques Gansler, Deputy Assistant Secretary of Defense (Material Acquisition), Office of the Assistant Secretary of Defense (Installations and Logistics), commented that the traditional approach had been "...best performance that technology can provide--cost being, at best, a secondary consideration" (36:4). Earlier, Dr. Foster is reported to have said:

"...we must change the objectives of the research and development community emphasis on improving the state of the art in performance, to an emphasis on quality equipment having an acceptable performance for an affordable cost" (48:29).

This bias against adequate performance is illustrated in the A-10. During that program a dispute between the best performance at a higher cost and satisfactory performance at a lower cost had to be resolved by the Chief of Staff of the Air Force (38:52-53). Another part of the bias results from a lack of confidence in the validity of the cost goals. This was noted in a Government Accounting Office report on Life Cycle Costing and appears to be applicable to Design to Cost as well (44:9). Finally there is the normal resistance to change, which occurs when any new concept or approach is introduced.

One of the major deficiencies of past acquisitions has been "buy-in" bidding. One goal of Total Package

Procurement was to eliminate this practice. In Design to Cost this practice could become "performance buy-in". In this situation the contractor might promise great performance at the Design to Cost goal, but then fail to match his claims with results after getting the contract. This problem can be partially eliminated through the use of contractor "flyoffs" of prototypes to determine how well promises match results.

Another possible deficiency of the Design to Cost concept may be a failure to include versatility in the system, because it adds to the cost of the system. The General Accounting Office during a review of Design to Cost considered the concept's possible impact on versatility. In its report it concluded:

"Design to Cost may limit opportunities to design weapons with built-in potential. It may also reduce instances where a weapon is designed to carry out more than one mission or satisfy multiservice needs..." (9:12).

The Department of Defense has recognized this potential deficiency. In its response to the report it indicated that the DSARC would during DSARC reviews examine each new system for multimission or multiservice possibilities and also for possible system growth (9:14).

There may be a tendency to specify cost goals too deeply into the factory or manufacturing cost levels. If goals are established at levels too specific, the benefits of Design to Cost in contractor flexibility

and cost control might be adversely affected. As was pointed out earlier, the more that is specified the less flexibility the contractor has in meeting cost objectives (26:13).

Finally, Design to Cost may increase development costs. As was pointed out in the discussion of criteria, the concept requires sufficient development time and money to be used successfully. This potential need for more time and money could, therefore, be a weakness, because the program manager is working against budget and time constraints. Consequently his flexibility is limited, and he may be forced to make less than optimal decisions to stay within the budget and schedule constraints.

In this section several of the significant deficiencies of Design to Cost have been highlighted. They are summarized in Figure 9. This is not a complete listing of weaknesses, but it represents a synthesis of the major weaknesses associated with the concept. The intent was to provide a framework of reference for the program manager to use in his application of Design to Cost. These weaknesses represent the kind of pitfalls which await the manager, who does not carefully consider all of the nuances associated with the options facing him in applying Design to Cost.

Too Early Cost Goal Establishment

Restriction on Innovation and Use
of New Technology

Availability of Few Tradeoffs

Suboptimization

Institutional Bias Against Change

Performance "Buy-in"

Reduced Versatility

Too Detailed Factory Cost Goals

Increases in Development Costs

Fig. 9. Summary of Design to Cost Weaknesses

VI. A Comparative Analysis of the Concepts

In previous chapters the concepts of Total Package Procurement, Life Cycle Costing, and Design to Cost have been analyzed individually. In this chapter the similarities and differences of the concepts will be presented. However, before accomplishing a comparison, the basic objectives of each concept will be reviewed.

Total Package Procurement was the first concept analyzed. Its main objective was to eliminate cost overruns in system acquisition. It attempted to achieve this objective by (1) extending contractor competition beyond the design stage of a system's development, (2) establishing firm performance requirements, schedules, and production quantities, and (3) using a firm fixed price contract as the basis for contract award.

Life Cycle Costing was the next concept analyzed. Its main objective is to attempt to determine the total costs of acquisition and ownership of a system over its full life and then use this information as an aid in decisions concerning acquisition. Total cost includes the cost of development, acquisition, operation, support and where applicable, disposal.

The emphasis in Life Cycle Costing varies through the acquisition life cycle. During the conceptual phase, the concept aids in assessing designs for cost effectiveness, and provides a baseline estimate for

use in tradeoff analyses. In the validation phase the cost information obtained from Life Cycle Costing is used to determine the most cost effective alternatives and to aid in source selection. In the other phases the total cost information helps establish the validity of the techniques used to make initial estimates and to provide bases to develop better cost effectiveness in future systems.

Design to Cost was the last concept analyzed. The primary objective of this concept is to obtain systems with acceptable performance at affordable costs. The concept emphasizes that cost should have equal importance with performance and schedules as design parameters.

Review of the concepts has determined that a direct comparison between all of the concepts is not appropriate. Total Package Procurement and Design to Cost have characteristics that indicate that a comparison is appropriate between them. These characteristics include similar design specifications, type of program office involvement, similar technological risks, similar criteria, similar strengths, and similar weaknesses. On the other hand, Life Cycle Costing because of its pervasive nature cannot be compared directly to either of the other concepts. However, there are certain areas of significance where Life Cycle Costing should be examined beside the other concepts.

This writer has reached this conclusion concerning Life Cycle Costing for the following reasons. First, Life Cycle Costing is a key part of both of the other concepts. In a 1967 study of Total Package Procurement, a Logistics Management Institute report stated: "The concept of Life Cycle Costing should be an integral part of the Total Package Procurement concept" (84:18). The Cost to Produce Handbook has also stated: "...in principle, Design to Cost should be practiced on a life cycle cost basis" (26:10). Second, Total Package Procurement and Design to Cost are directed toward establishment of specific cost goals or objectives, while Life Cycle Costing is oriented toward being a general aid to decision making. The other concepts establish specific requirements or goals in application, then use Life Cycle Costing to project the total costs resulting from these specifications. Life Cycle Costing does not specify requirements; it estimates costs of specified requirements. Finally, Total Package Procurement and Design to Cost can be considered as methods to be used to restrain cost growth, while Life Cycle Costing can be considered as a technique to be used as an aid in application of the other concepts.

Total Package Procurement and Design to Cost - Similarities

In this section the major similarities between

the two concepts will be identified. These similarities can be grouped into the following areas:

1. Low Technological Risk.
2. Specification of Design.
3. Extension of Competition.
4. Means to Restrain Cost Growth.

Low Technological Risk. The criteria for both concepts specified that the concepts should be applied to programs with low technological risk. In both concepts application to systems with substantial unknowns could result in a failure to meet the specified costs or cost goals.

Specification of Design. In this area this writer means performance requirements, schedules, and production quantities. Both concepts depended on a detailed specification of each area, but they differed in the application of the specification. In Total Package Procurement the contract identified each requirement, before development contracts were awarded. The results were fixed prices, performance requirements, schedules, and production quantities. Design to Cost does not go that far. Cost goals are established based on specified performance requirements, price, and production quantities, but they are not fixed. No contracts are awarded based on the early cost goals. They are objectives to be strived for during the design and early development of the system. In Design to Cost

prices, performance requirements, schedules, and production quantities are not fixed until a system enters the production phase.

Extension of Competition. Both concepts are designed to extend contractor competition during the acquisition life cycle. Total Package Procurement extended competition explicitly, while Design to Cost did it implicitly. Under Total Package Procurement the Request For Proposal specifically indicated to the competing contractors that they were bidding for the development, production, and some support of the system - the Total Package. On the other hand, Design to Cost uses the cost goals for production, operation and support to implicitly extend competition. While the Request For Proposal does not indicate a commitment by the government to anything beyond the validation phase, the competing contractors know that anticipated production, operating and support costs will be important factors in source selection. Consequently they are motivated to design for economical production, improved reliability and simplicity of maintenance and operation. The final result is that, in effect, the contractors are competing for the total program, just as was done in Total Package Procurement.

Means to Restrain Cost Growth. Both concepts have the common aim to restrain cost growth. However, their approaches are different. Total Package Procurement

proposed to restrain cost growth through the use of a firm fixed price contract. Design to Cost proposes to restrain growth through the use of cost goals. The main difference between these approaches is flexibility. Design to Cost is not tied down by decisions based on paper designs, as was Total Package Procurement. Consequently it more responsive to changes in direction, which may occur as the sytem is more clearly defined during its development.

Total Package Procurement and Design to Cost - Differences

In this section major differences between the two concepts will be examined. These differences can be grouped into the following areas:

1. Decision Strategy.
2. Tradeoff Flexibility.
3. Program Office Involvement.
4. Degree of Contractor Risk.

Decision Strategy. One of the most important differences between Total Package Procurement and Design to Cost is the decision strategy. Total Package Procurement involved a single point decision. A contractor was selected for the development, production, and support of a system with a fixed price, production schedule, production quantities, and performance requirements by a single decision.

On the other hand, Design to Cost uses a phased

Total Package Procurement	Design to Cost
1. Single Decision Point	Several Decision Points
2. Inflexible	Emphasizes Flexibility
3. Program Office "Hands-off" Policy	Program Office Emphasizes Active Interface with Contractor
4. High Contractor Risk	Low Contractor Risk

Fig. 10. Differences Between Total Package Procurement and Design to Cost

decision approach. At the end of the conceptual, validation, and full-scale development phases new decisions are required to proceed into the next phase. The following flow illustrates this approach. At the beginning of the validation phase qualified contractors are provided funds to design a system to meet specified performance and cost goals with no commitment for further activity. At the end of the validation phase the program is evaluated to determine if it should be continued. If it is decided to proceed, the contractor with the most cost effective design, as identified during the validation phase, is provided with funds to proceed with full-scale development of the system. Again there is no commitment that the program will proceed further. Dependent on the results of this phase a contract for production may or may not be negotiated. If a contract is negotiated, it will normally be a firm fixed price plus incentive fee contract. As this flow has shown, Design to Cost is based on a series of decisions before a commitment to a program occurs. Whereas, Total Package Procurement involved a single decision based on proposed designs with no hardware development.

Tradeoff Flexibility. Total Package Procurement required that specific performance commitments be specified in the contract. These commitments were based on paper assessments. The result was that in

actual hardware development the contractor had virtually no flexibility to tradeoff between performance and cost in resolving unanticipated problems. These problems might require renegotiation of the basic contract.

Design to Cost emphasizes maximum tradeoff flexibility in meeting cost goals. In Design to Cost as few performance requirements, as possible, are specified. This permits the contractor flexibility in devising the best way to meet the performance goals and still satisfy the cost goals for the system.

Program Office Involvement. Another major difference is program office involvement. In Total Package Procurement the intent was to remove the government from active involvement in the contractor's efforts. On the other hand, Design to Cost emphasizes the active interface of the program office with the contractor to assure maximum flexibility in meeting cost goals through design tradeoffs.

Degree of Contractor Risk. Total Package Procurement increased the financial risks of the contractor. The contractor competed for a fixed price contract in a price competitive environment. Contractor risk was also increased by the long term of the contract. As the C-5A program illustrated, changes in the economy quickly affected the contractor. On the other hand, Design to Cost has relatively low

financial risk for the contractor. There is no long term fixed price commitment, so the contractor is not adversely affected by economical changes.

This comparison of Total Package Procurement and Design to Cost has shown that the concepts are quite similar. They both were directed primarily toward restraining cost growth in system acquisition. They also emphasized the need for definitive specification of performance requirements, schedules, and production quantities early in the acquisition life cycle. The most significant differences are decision strategy and cost specification. Total Package Procurement used a single decision strategy, while Design to Cost used a multiple decision strategy. Total Package Procurement set a firm price on the system, while Design to Cost set a price goal.

Next the Life Cycle Costing concept will be examined beside Design to Cost. It will not be analyzed specifically with Total Package Procurement, because that concept is no longer in use. However, since a close similarity between Total Package Procurement and Design to Cost exists, it can be assumed that similar conclusions would be reached, if Life Cycle Costing and Total Package Procurement were analyzed together.

Life Cycle Costing and Design to Cost

This writer's analysis of Life Cycle Costing and Design to Cost has determined that Design to Cost goals can be considered specialized derivations of Life Cycle Costing. The Design to Cost concept attempts to establish specific cost goals on the acquisition, operation and support costs of a system. The cost goals, which are established, are determined in part through the use of life cycle cost estimates. The Cost to Produce Handbook states "...in principle, Design to Cost should be practiced on a life cycle cost basis" (26:10).

The Joint Design to Cost Guide indicates that life cycle costs must not be ignored during application of Design to Cost. It also adds:

"A life cycle cost estimating model which is sensitive to reliability and maintainability characteristics may be used to give visibility to the effect design changes have on unit production costs and on estimated life time logistics support costs" (42:7).

No specific comparison of Life Cycle Costing and the other concepts will be accomplished. Instead significant areas of interest will be examined to see how the concepts are interwoven and also how they differ.

The areas to be examined include,

1. Design Specification.

2. Application During the Acquisition Life Cycle.
3. Dependent or Independent.
4. Means to Restrain Cost Growth.

Design Specification. Design specification refers to performance requirements, schedules, and production quantities. Application of both concepts depends on an identification of each of the elements of the design specification, but the reasons for specification differ. In Design to Cost the design specifications are identified and then used to designate the cost goals. However, the cost goals may determine design specifications. Situations where cost goals determine design specifications can occur when only a specified amount of funding is available for a system. Life Cycle Costing, itself, does not specifically cause the identification of design specifications or cost goals. It merely provides estimates of the costs resulting from identified design specifications. Design specifications may be changed as a result of the estimates provided by life cycle cost models, but Life Cycle Costing, itself, does not specify the design. It is a technique used by the decision maker to aid in the specification of designs.

Application During the Acquisition Life Cycle.

Both concepts can be applied at the same time in the acquisition life cycle. However, life cycle costs are

determined in phases of the acquisition life cycle, where Design to Cost goals are no longer relevant.

In the conceptual phase both concepts are used. Life cycle cost estimates provide a general baseline of what costs may be for the system. This information assists the Design to Cost user in estimating the first tentative cost goals.

In the validation phase both concepts are used. During this phase the specific cost goals are established for a Design to Cost program. Life cycle cost estimates provide much of the data needed to establish the cost goals.

In the full-scale development phase both concepts are used. During this phase the earlier estimates are validated as the system is evaluated. At the end of this phase the Design to Cost goals are compared with the design specifications and a decision is made on whether or not to proceed with production. Once a decision is made Design to Cost ceases to be used as a factor.

In production and deployment the Life Cycle Costing concept is still used to gather data to determine how actual costs compare with previous Design to Cost goals and to provide data for use in the development of future systems.

Dependent or Independent. Another area of interest is the question of whether or not the concepts should

be used independently of each other? Design to Cost should not be used without the Life Cycle Costing concept. Attempts to use Design to Cost without consideration of possible life cycle cost effects can result in suboptimization. This potential danger is reduced when life cycle cost estimates are utilized in Design to Cost.

On the other hand, it is not necessary to have Design to Cost goals identified to use Life Cycle Costing. In fact cost goals are not a factor in life cycle cost estimating models. Life Cycle Costing can be applied to any system or subsystem or component, regardless of whether any other concept might be applicable.

Means to Restrain Cost Growth. Life Cycle Costing is a key part of efforts to restrain cost growth. The other concepts are, in fact, dependent on life cycle cost estimates in their efforts to restrain cost growth. Estimates of total costs can (1) aid in the selection of systems with the greatest reliability and maintainability, (2) assist in providing tradeoff flexibility, and (3) lead to future improvements in cost effectiveness. All of these items restrain cost growth in system acquisition.

In this section significant areas of interest involving the Life Cycle Costing and the Design to Cost concepts have been examined. The intent was

to (1) show the close relationship between the concepts, and (2) highlight differences between the concepts.

In this chapter several major areas concerning the three concepts were compared. It was shown that Total Package Procurement and Design to Cost have many similar characteristics. The major differences between the two concepts were also identified. It was also established that Life Cycle Costing is not as specific an approach to acquisition, as are Total Package Procurement and Design to Cost. It is rather a technique to be used in the application of the other concepts to restrain cost growth. However, the other concepts are dependent on Life Cycle Costing for effective implementation.

VII. Conclusions

In this thesis a historical analysis of Total Package Procurement, Life Cycle Costing, and Design to Cost was accomplished. Based on this analysis some conclusions regarding each concept can be made. Those conclusions will be presented in this chapter.

Total Package Procurement

Total Package Procurement was the first major approach developed by the Department of Defense as an effort to restrain cost overruns in systems acquisitions. However, it became discredited as an approach after being used for a short time.

A retrospective view of the concept indicates that, while the goal of the concept was desirable, the quantum leap, which implementation of the concept represented, was a factor in its failure. Total Package Procurement was an effort to change 30 years of acquisition in a single step. It depended on details and projections never before attempted on large programs. For example, it required detailed specification of performance requirements, schedules, and production quantities, even before a single piece of hardware was built. It also required that the contractors project requirements far into the future with no provision for revision. Finally it attempted to set a firm price on the development and production of a

complex system, before any part of that system was constructed.

If the concept had been implemented in a more orderly fashion, it may have been successful. The concept was introduced in mid 1964 and contractors were asked to submit bids for a billion dollar program using the concept a few months later. It is this writer's opinion that inadequate time was provided for both the government and the contractors to develop an understanding of the implications of the concept. This was evidenced by the failure to realize that long range projections were only estimates. Provisions should have been included in the concept for contract revisions based on what actually occurred.

Another major deficiency of the concept was its lack of flexibility. The setting of firm fixed prices on paper designs provided virtually no flexibility to respond to events, as the system was actually built.

It is this writer's view that Total Package Procurement tried to do too much in a single massive effort to restrain cost overruns. However, the lessons learned from Total Package Procurement have aided in the development of its replacement - Design to Cost. However, before looking at Design to Cost, the Life Cycle Costing concept will be reviewed. It overlaps both concepts and is a key factor in the implementation of both.

Life Cycle Costing

Life Cycle Costing began to be an important factor in systems acquisition in the mid 1960's. It is a technique, which estimates the total costs associated with a system which has a specific design. It is much broader in application than the other two concepts. Total Package Procurement and Design to Cost emphasized specifics, such as performance requirements, costs, schedules, and production quantities, while Life Cycle Costing estimates the total costs associated with these specifics.

It is this writer's judgement that accurate life cycle cost estimates are the key to restraining cost growth in systems acquisition. Accurate cost estimates provide the manager with the information needed to make acquisition decisions. Unfortunately a high degree of confidence in these estimating techniques has yet to be gained. A General Accounting Office report of December 1974 on Life Cycle Costing indicated that there appeared to be "...lack of guidelines on costs to be included in an ownership estimate" (44:11). Mr. Bennett, in the January 1976 issue of the Defense Management Journal, commented "Refinement of terms, conditions, requirements, and data validity and availability is badly needed" (11:3). These comments illustrate that more confidence in cost estimates still is needed.

Life Cycle Costing, whether alone or in conjunction with Design to Cost, has great potential for achieving cost control in systems acquisition. It can provide early information, which the program manager can use to restrain cost growth. In this writer's judgement it will be used more and more as an acquisition aid, as confidence in its estimating abilities increases.

Design to Cost

The last concept developed to control acquisition costs was Design to Cost. It was developed as the replacement for Total Package Procurement. It was developed using the lessons learned during Total Package Procurement. Design to Cost takes a more realistic approach toward cost control than Total Package Procurement. It does not set firm fixed prices, and it gives the contractors much more flexibility. The concept uses cost goals, instead of fixed prices, to maintain cost control. These cost goals are both good and bad. They are good because they restrain cost growth, but they are bad because they may limit development of a system. This limiting can occur when the goals are treated as ceilings rather than goals. If the goals are used as ceilings, the manager has little flexibility to use possibly more expensive technological advances in development of a system. Additionally the manager may not want to fight the

battle to get the goal raised to take advantage of the advance. This is potentially a serious deficiency of the concept.

At this point in the use of Design to Cost this writer has concluded that it represents a realistic approach to system acquisition. Design to Cost makes the manager define the specifics of the system early in the program. This ensures the system being developed is the system that is needed. Additionally the concept provides for a better projection of needs and the availability of funds to satisfy those needs. Finally, it makes the manager consider the operating and support costs of the system, not just the system's acquisition cost. All of these factors should combine to eliminate or as a minimum substantially reduce cost growth in systems acquisition.

In this analysis this writer has traced the evolution and development of the approaches introduced to impose cost control over the acquisition process. It is obvious that cost control is necessary, because of the increasing costs of new systems. The question is - are the present approaches the right ones? It is this writer's judgement that Design to Cost and Life Cycle Costing as a team can achieve cost control in acquisition. It is also this writer's judgement that these concepts do represent the best approaches to the control of costs. But a cautionary note must

be added. Any concept must have the active support of the command hierarchy and it must be used by the working level managers. With either of these elements missing the concepts will be little more than "buzz-words" in the Department of Defense lexicon.

Finally, Life Cycle Costing and Design to Cost do cover the spectrum of the acquisition life cycle and represent a disciplined approach to systems acquisition.

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